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Processing TENCEL® fibers

Processing of various cut staples at different delivery speeds on the Rieter air-jet spinning machine using TENCEL® fibers

Introduction

This study was conducted in the context of the close cooperation between Rieter and Lenzing.

It presents the findings obtained with TENCEL® fiber in different cut staple lengths in order to establish whether the quality of an air-jet spun yarn can be influenced by using longer fibers. This study sets out the influencing factors up to downstream processing of the yarn.

Type of raw material

Due to the wide range of application of this raw material, Tencel fiber with 1.3 dtex fineness in different staple cut lengths was used.

The raw material components featured fiber specifications in general use. The cross-sectional and longitudinal views of the fiber used are shown in Fig. 1.

Tencel®
Bright

Fiber fineness:	1.3 dtex
Classifier's staple:	36, 38, 42, 44 mm
Strength:	38 cN / tex
Elongation:	12 %

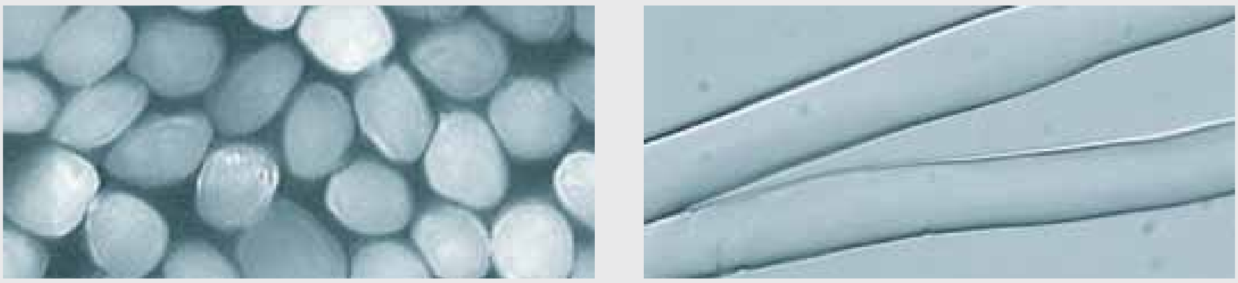

Fig. 1 Fiber specifications

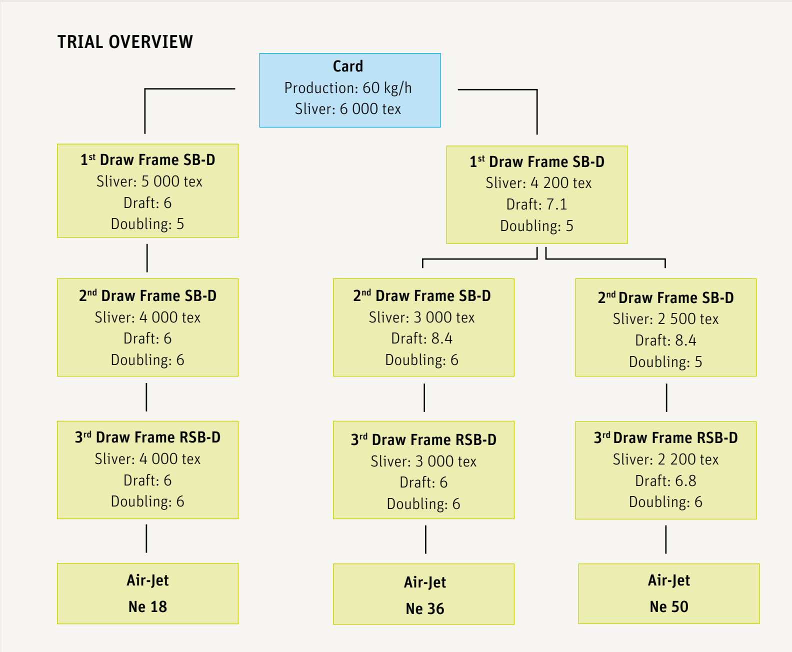

Fig. 2 Test setup

Test setup

The overview shows the test setup for processing the different cut staples to manufacture differing yarn counts of Ne 18, Ne 36 and Ne 50. The optimal spinning plan was selected for each yarn count (Fig. 2).

Raw material analysis

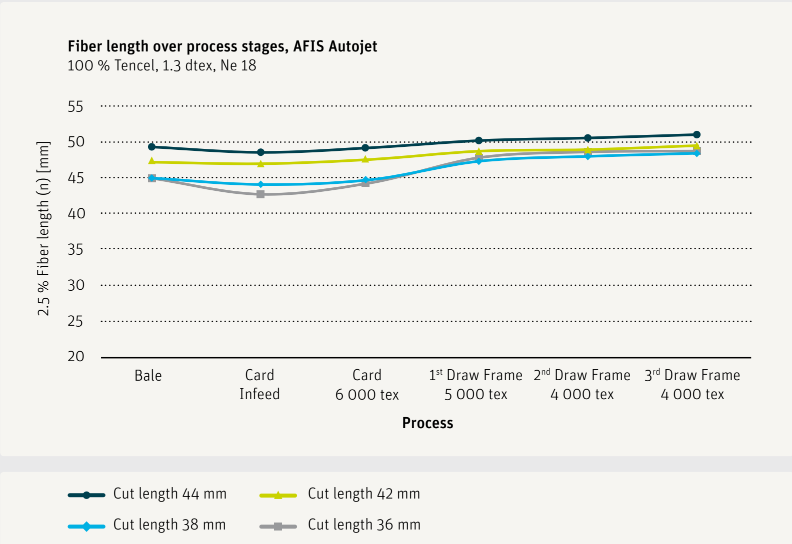

Fig. 3 Increase in fiber length

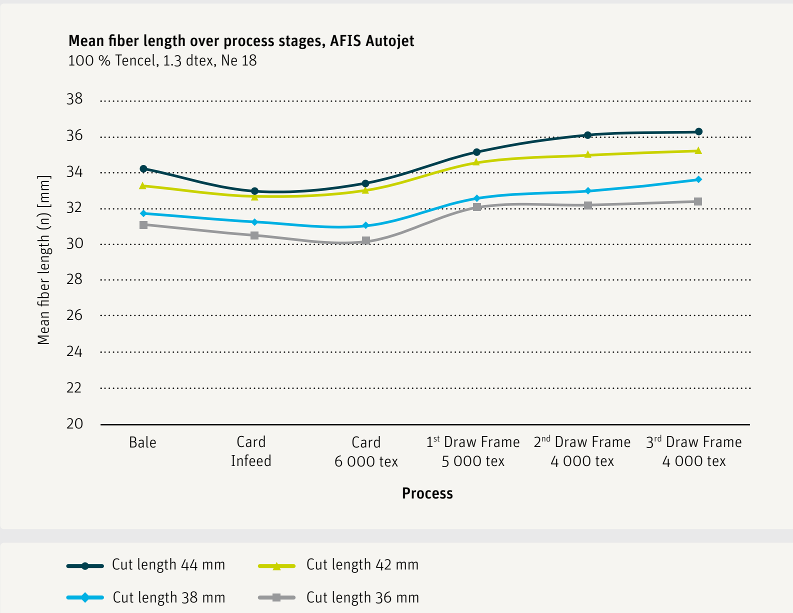

Fig. 4 Mean fiber length

Fiber length

With different cut staples, drawframe settings in fiber preparation and ultimately on the final spinning machine must be adjusted in each case depending on the long fibers.

For purposes of raw material analysis the length of fibers occurring in the fiber bundle with a frequency of 2.5 – 5 % were taken into account.

At a frequency of 2.5 % it is apparent that fiber length increases by approx. 1-2 mm over the process stages due to fiber orientation and crimp removal. Different spinning plans were selected, depending on the final yarn count (Ne 18, Ne 36 or Ne 50). The increase in fiber length was observed in all spinning plans used. Only the fiber values measured on the basis of the spinning plan for Ne 18 are shown as representative (Fig. 3).

Fiber orientation can be identified from the mean fiber length and the short fiber content over the subsequent process stages.

Fiber length measurement is influenced by the degree of fiber parallelization.

The mean fiber length measured increases by approx. 2 mm over the subsequent process stages and the short-fiber content declines by approx. 1 % due to parallelization (Fig. 4).

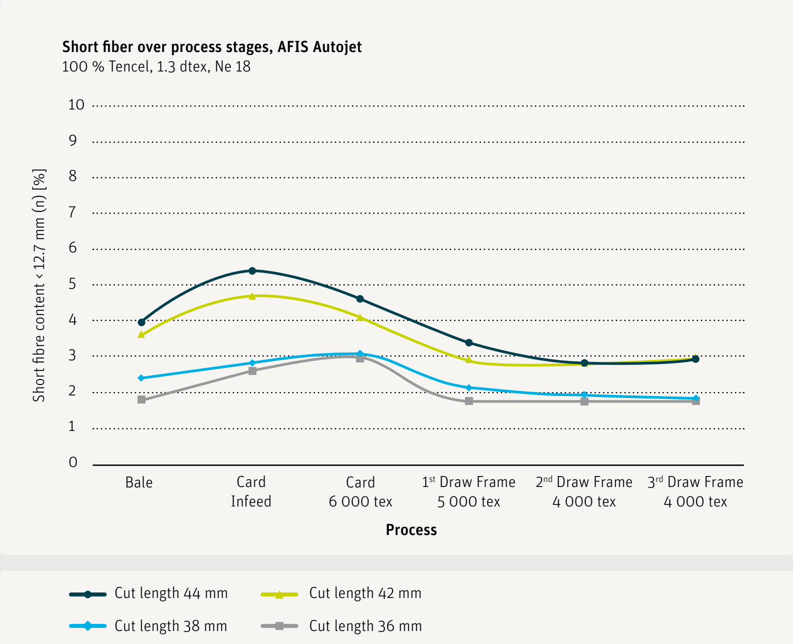

Fig. 5 Short-fiber content depending on staple length

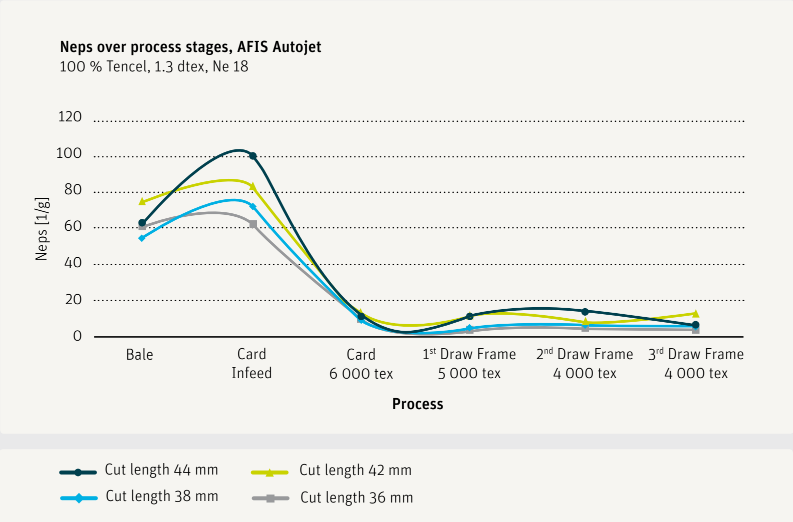

Fig. 6 Number of neps over the process stages

However, it is also apparent from the measured values that no fiber damage has therefore occurred during the carding action. This can be attributed to the low card output of 60 kg/h.

However, on the basis of these findings an optimal carding output of 80 kg/h is assured with a cut staple of 38 mm, 1.3 dtex and a final spinning count of up to Ne 40 for air-jet spinning (Fig. 5).

Neps

Fiber opening and fiber transport via the suction duct system usually result in an increase of approx. 30 % in fiber neps in the spinning mill. Optimal carding and subsequent parallelization reduce/untangle approx. 90 % of the fiber neps again (Fig. 6).

The measured values also show that the incidence of neps in the different fibers also depends on cut length with the same fiber fineness. The ratio of fiber length to fiber diameter determines the fineness ratio. The higher the fineness ratio, the greater the risk that neps will occur.

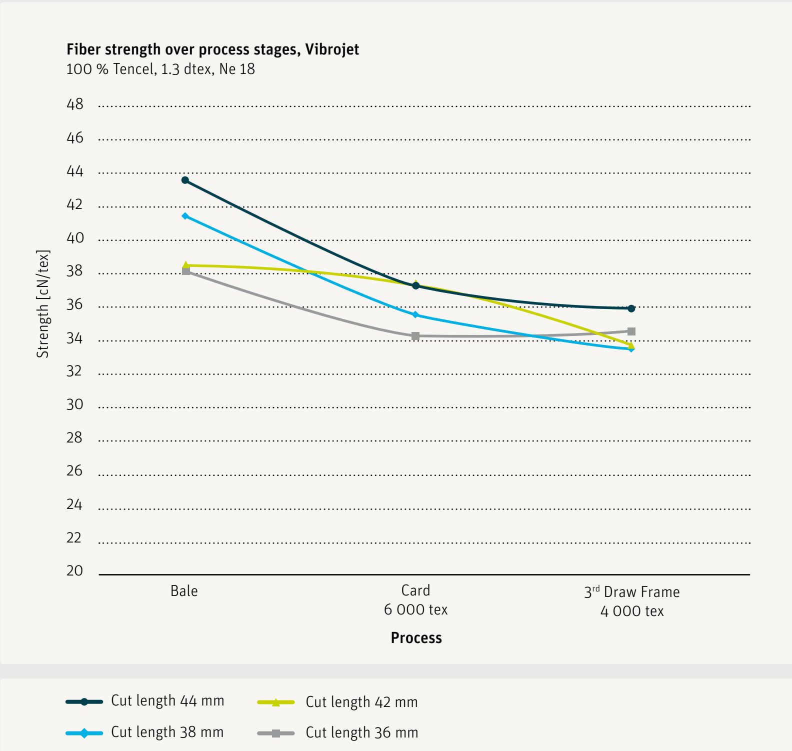

Fig. 7 Fiber strength over the process stages

Fig. 8 Fiber elongation over the process stages

Fiber strength/elongation

A loss of 10-11 % in fiber strength of the TENCEL® fiber can be observed due to the carding process, which can be regarded as normal. Depending on the spinning plan, fiber strength declines by a further 2-3 % in the subsequent drafting passages (Fig. 7).

On the basis of the different spinning plans for the different yarn counts, it is apparent that fiber stress in the drafting pass is also minimally affected by the fiber mass in the drafting system. It is apparent that the fiber mass, i.e. sliver count, has a minimal influence on fiber stress.

Fiber elongation declines by 2-3 % in absolute terms in the course of the carding process (Fig. 8). This reduction can be regarded as a very good outcome. Fiber strength and elongation are measured as a function of fiber raw material and fineness. Fiber length plays no part in this as long as optimal drafting system distances are selected.

Sliver irregularity

The study shows that the longer cut staple lengths of 42 & 44 mm exhibit an insignificant difference in irregularity in the sliver (fiber bundle) in comparison with 36 & 38 mm. The lower the sliver weight selected in the various spinning plans, the higher the irregularity due the smaller fiber mass.

When a third drafting passage is used, sliver irregularity is 2.5 CVm (%), despite the differing sliver counts for the different final spinning counts and the different cut staple lengths.

Irregularity is therefore in a very good range and meets the relevant requirements for air-jet spinning technology (Fig. 9a, 9b, 9c).

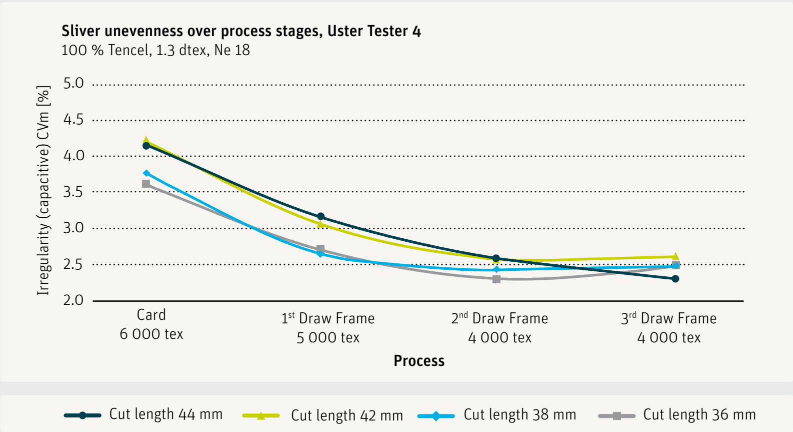

Fig. 9a Sliver irregularity over the process stages

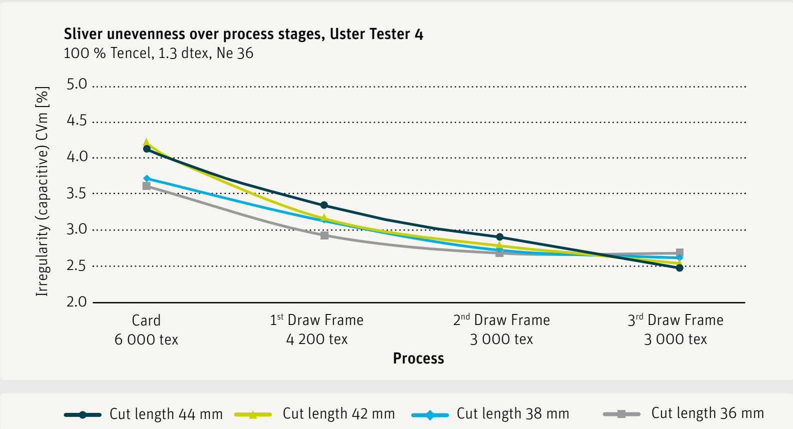

Fig. 9b Sliver irregularity over the process stages

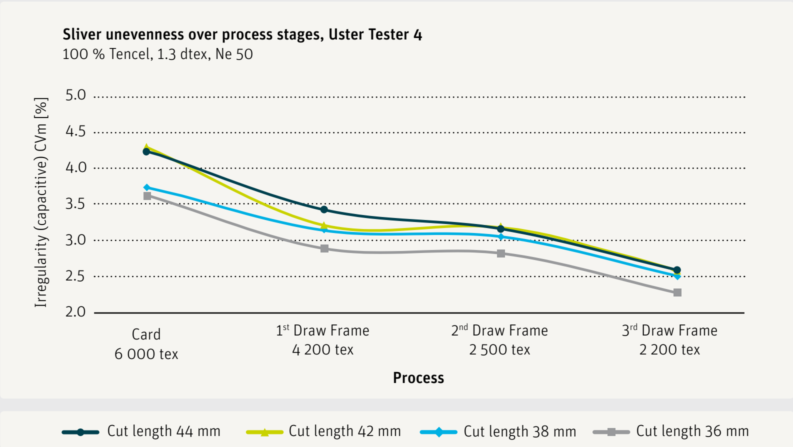

Fig. 9c Sliver irregularity over the process stages

Fig. 10 Staple diagram of the different cut staples

Effectiive Distance

Staple length [mm]	Total draft	Ne	Pre Draft		Middle Draft		Main Draft	
			Draft	Distance	Draft	Distance	Draft	Distance
	124	18			2.3		31	
36	191	36	1.76	45	2.6	43	47	49
	190	50			2.6		41	
	124	18			2.3		31	
38	191	36	1.76	49	2.6	46	47	48
	191	50			2.6		41	
	124	18			2.3		31	
42	191	36	1.76	50	2.6	47	47	52
	191	50			2.6		41	
	124	18			2.3		31	
44	191	36	1.76	50	2.6	47	47	52
	191	50			2.6		41	

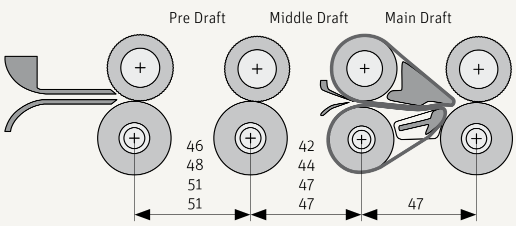

Fig. 11 Draft settings (break, intermediate and main draft)

Drafting system settings on the air-jet spinning machine

It is well known that "cut staple" never produces a rectangular staple, since this would have a negative impact on the drafting behavior of the fibers in the drafting systems. The staple diagrams of the various cut staples each display an appropriate distribution of fiber lengths (Fig. 10).

However, with regard to the drafting system setting it must be noted that a portion of the fibers is much longer than the stated cut staple. It is evident that 5 % of the fibers are at least 4 mm longer.

A further increase in the actual fiber nip line length can result from the parallelization and crimp removal that takes place. This has to be taken into consideration when setting the drafting system on the air-jet spinning machine.

The drafting system distances and degrees of draft were defined in preliminary trials on the basis of design conditions. These indicate the following appropriate settings in the context of the prevailing technical conditions:

The drafting system on the air-jet spinning machine is designed for cut staple of 38-40 mm, which corresponds to a 5 % staple of 42-44 mm (Fig. 11).

The proportion of 38 mm cut staple by volume is estimated at 80 % of global staple fiber production.

Total draft on the air-jet spinning machine was specified at a maximum of 190 times at the beginning of the trials on the basis of previous experience. The main draft for the various yarn counts of Ne 18, Ne 36 and Ne 50 was therefore between 31 and 41 times.

It was apparent from the preliminary trials that primarily the yarn count was of decisive importance for optimum distance “A” (Fig. 12), and not the fiber length of the different cut staples used. This finding relates only to the Lyocell (TENCEL®) raw material used and the relevant cut staples of 36, 38, 42 and 44 mm.

The following setting was chosen on the basis of the preliminary trials:
21.6 mm = A + 1 for Ne 18
19.6 mm = A – 1 for Ne 36 and Ne 50

Nozzle and distance	Raw material	Yarn count range
A–1, 19.6 mm	Tencel	Ne 36–Ne 50
A+1, 21.6 mm	Tencel	Ne 18

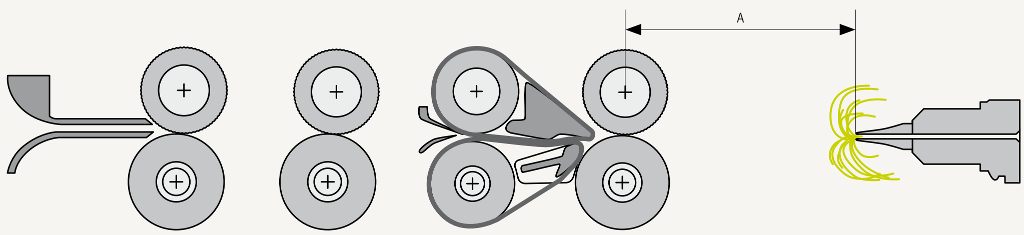

Fig. 12 Spinning nozzle spacing

Yarn results

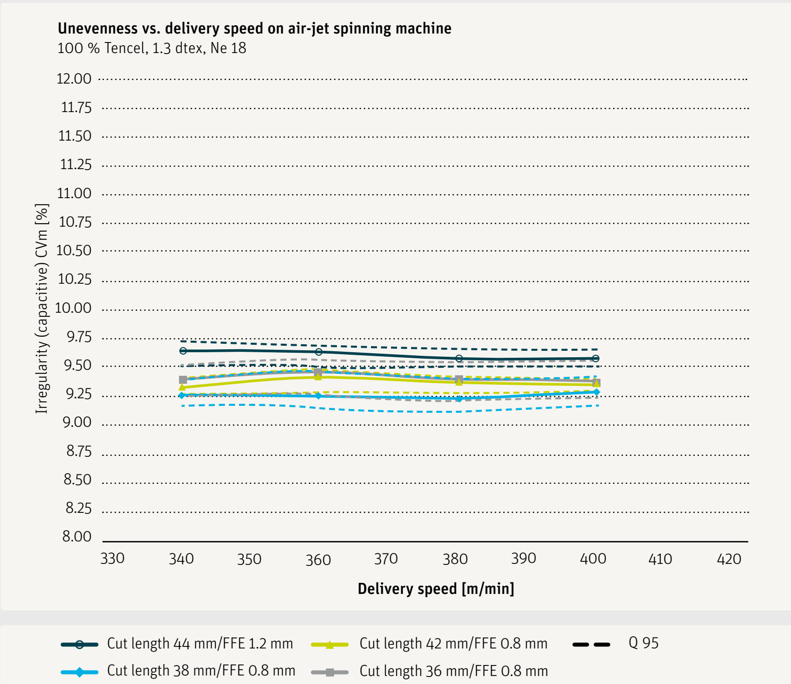

Fig. 13 Yarn irregularity

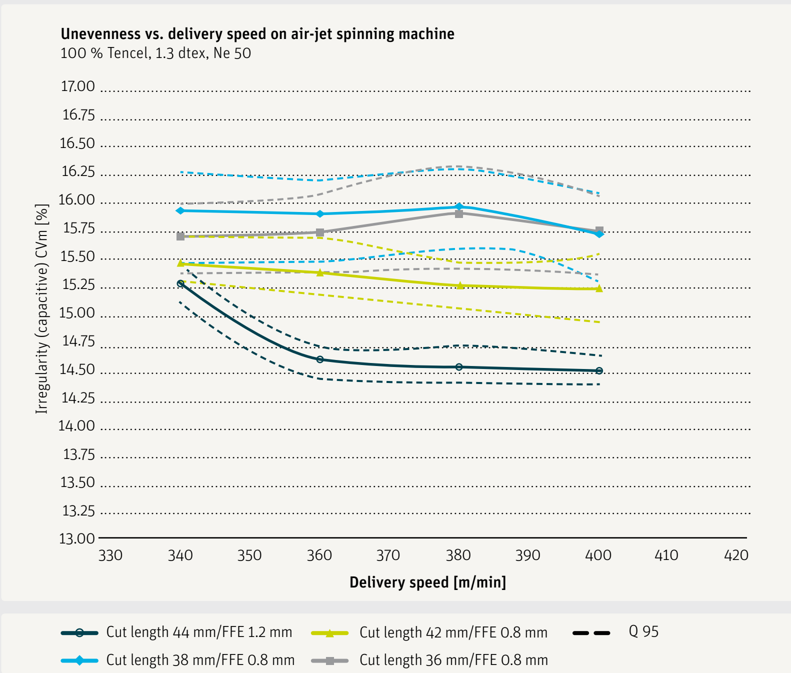

Fig. 14 Yarn irregularity

Irregularity

Yarn irregularity is not affected – or only minimally – by the delivery speed of the air-jet spinning machine with a yarn count of Ne 18 (Fig. 13).

Better regularity is only achieved with increasing cut staple length in a finer yarn (Ne 50). A longer cut staple thus only displayed better regularity measurements with finer yarns. Fiber integration, i.e. irregularity, is thus affected by the combination of fiber mass and cut staple length.

It is also possible that the yarn structure has a greater influence on measured results in the case of coarser yarns. In this case thin and thick places (imperfections) can be detected which have an influence on irregularity readings (Fig. 14).

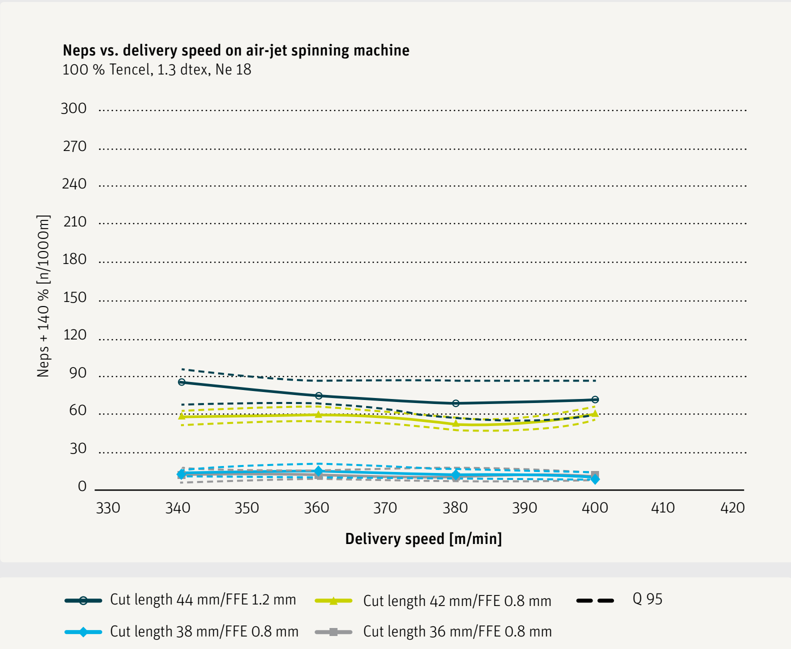

Fig. 15 Number of neps (140 %)

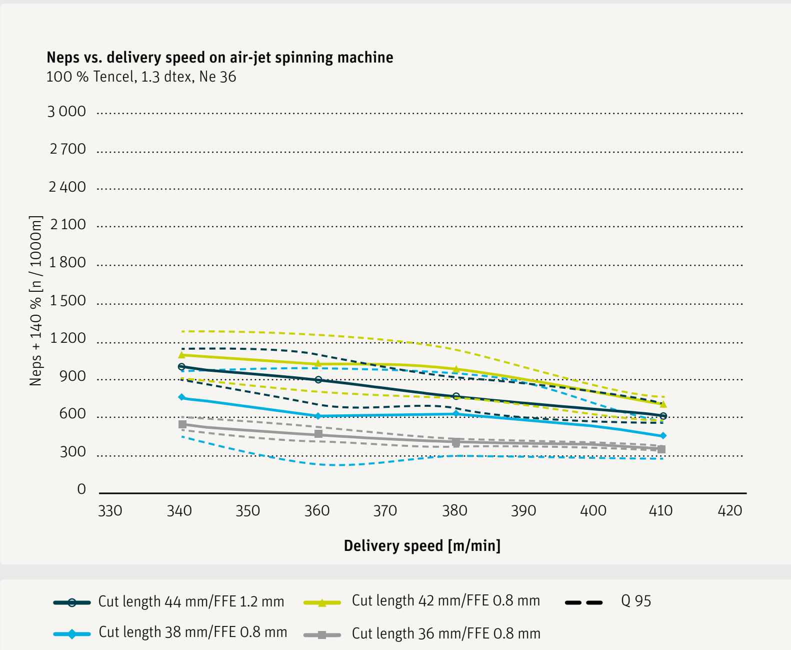

Fig. 16 Number of neps (140 %)

Imperfections

Fine neps (140 %) across the different yarn counts indicate that fewer neps are counted in the yarn with shorter cut staple lengths. This effect is attributable to the fineness ratio of the fibers (Fig. 15).

Longer fibers already result in a greater incidence of neps during fiber preparation with the same fiber fineness due to the fineness ratio, and this can be visible through to the yarn.

Depending on yarn count and staple length, the number of neps can also decline in relation to delivery speed, as with a yarn count of Ne 36 (Fig. 16). This effect was also observed with thick places and can be explained by changes in yarn structure.

However, in this case it is not a general phenomenon. Depending on the relation of yarn count to structural change, such effects can occur due to delivery speed. In such cases it is a matter of a more uniform structure being measured depending on yarn count, due to a smaller number of wrapping fibers per unit of yarn length.

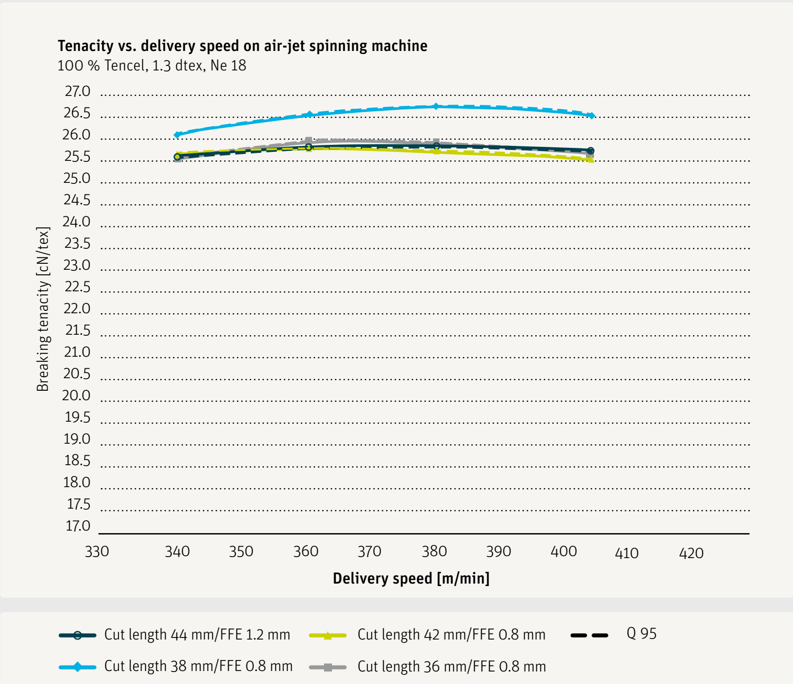

Fig. 17 Yarn tenacity

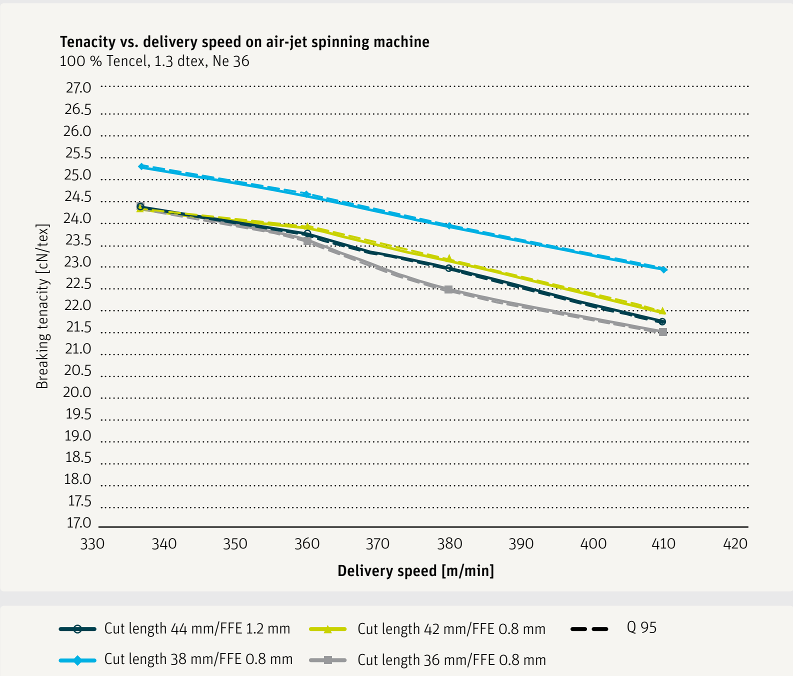

Fig. 18 Yarn tenacity

Yarn tenacity

A longer cut staple displays no general advantage in terms of yarn tenacity in yarn counts of Ne 18-36.

Up to 1 cN/tex higher yarn tenacity values were achieved in a yarn count of Ne 18 combined with the 38 mm cut staple (Fig. 17).

Yarn tenacity is clearly influenced by the delivery speed of the air-jet spinning machine, depending on yarn count.

In finer yarns, such as Ne 36 and Ne 50, yarn tenacity declines steadily by up to 2 cN/tex with increasing delivery speed (Fig. 18).

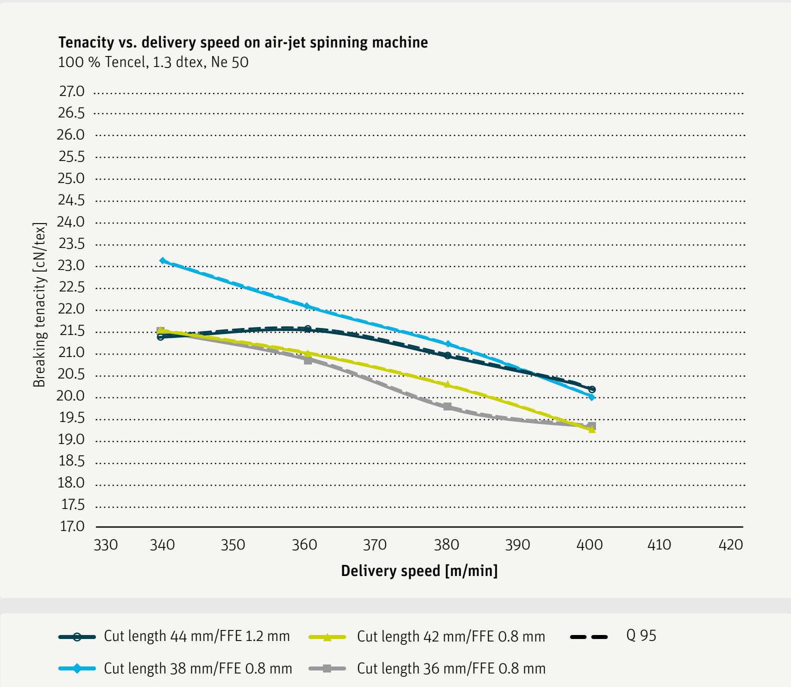

Fig 19 Yarn tenacity

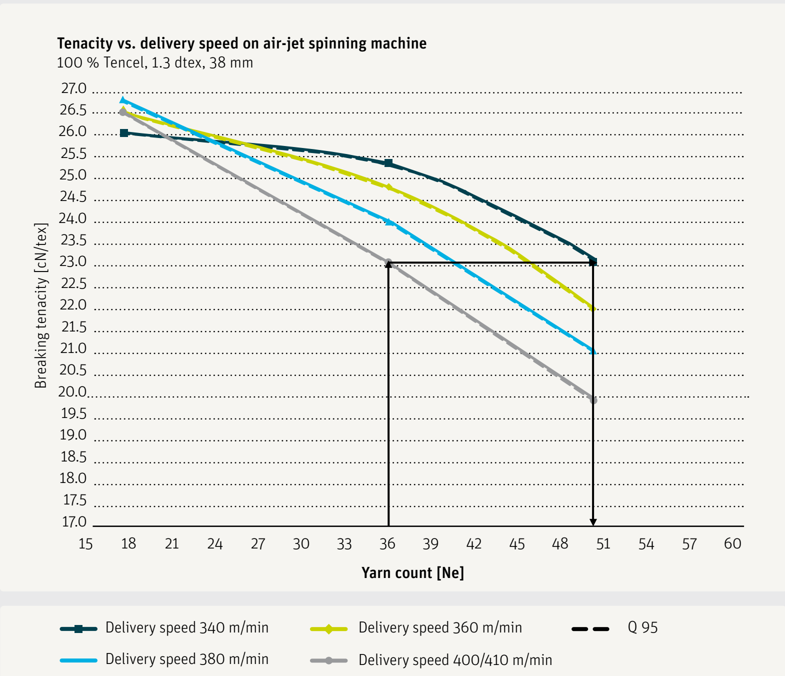

Fig 20 Yarn tenacity

This behavior can be explained by the fact that yarn twist changes depending on delivery speed, as in ring and rotor spinning, at the same rotation speed.

$$T/m = \frac{\textit{Fiber sun speed [rpm]}}{\textit{Delivery [m/min]}}$$

In general, the finer yarn counts should have a higher twist per unit length, in order to have the required tenacity for downstream processing. However, in the case of air-jet spinning this is not necessarily possible – or not to the required extent – via the elements imparting twist. That is to say, an increase in yarn twist cannot necessarily be achieved by way of a higher fiber sun speed.

Influences exerted on tenacity as a function of staple length are apparent in the study of yarn count Ne 50. The highest mean yarn tenacity was measured on a cut staple length of 38 mm.

Despite the different drafting system settings and adapted technology components on the air-jet spinning machine, the very good tenacity values of 38 mm cut staple were not exceeded by staple lengths of 42-44 mm (Fig. 19).

It should be pointed out here that 90 % of all cellulosic manmade fibers are produced with a cut staple length of 38 mm.

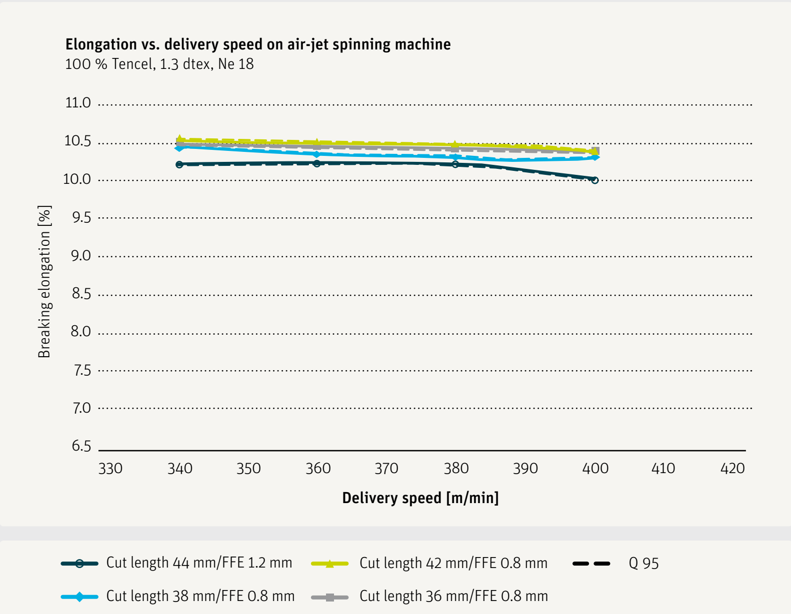

Fig. 21 Yarn elongation

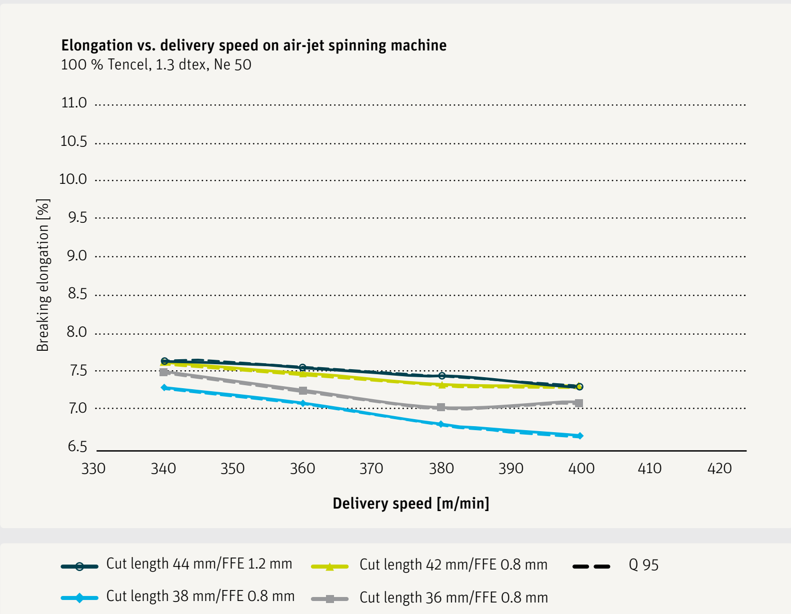

Fig. 22 Yarn elongation

Declining tenacity in finer yarns is also attributable to the decline in the number of fibers in the cross-section. This is clearly apparent in Fig. 20. Higher yarn tenacity can be achieved in finer yarns by reducing the delivery speed of the air-jet spinning machine.

In order to maintain the same yarn tenacity of 23 cN/tex in a yarn count of Ne 36 at 410 m/min, delivery speed must be reduced to 340 m/min for an Ne 50 yarn count.

Yarn elongation

Cut staple length has no effect on yarn elongation in yarn counts of Ne 18 and Ne 36. The effect of high yarn mass on yarn elongation behavior outweighs that of delivery speed and yarn structure in this case (Fig. 21).

In principle, it can be stated that yarn elongation increases with

- longer cut staple
- finer yarn
- lower delivery speed

For example, with a yarn count of Ne 50 at a delivery speed of 400 m/min, approx. 0.5 % more yarn elongation occurs with cut staple lengths of 42-44 mm compared to cut staple of 36-38 mm (Fig. 22).

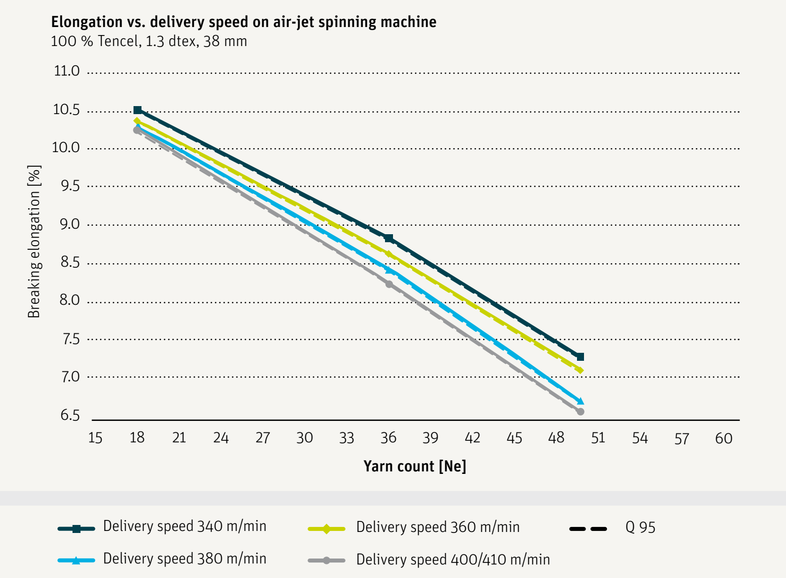

Fig. 23 Yarn elongation

Fig. 24 Weak places

Apart from the influence of yarn count, the effect of delivery speed is also apparent using 38 mm cut staple as an example (Fig. 23). Depending on yarn count, yarn elongation declines significantly with increasing delivery speed. For example, yarn elongation of Ne 50 at 340 m/min declines by 0.6 % in absolute terms when delivery speed is increased to 400 m/min.

The relationships clearly show that the stretch recovery of a yarn, as the product of its tenacity and elongation, can be considerably affected by the delivery speed of an air-jet spinning machine, depending on requirements for downstream processing of the yarn.

Weak places

The finer the yarn, the greater the positive influence of increasing cut staple length. The weak places in terms of tenacity and elongation relate to 0.1 % of the measured values.

The effect of delivery speed on the weak places only becomes apparent here with fine-count yarns such as Ne 36 and Ne 50, but not with coarser yarns such as Ne 18.

A large number of fibers in the yarn cross-section inevitably results in fewer weak places in the yarn. That is to say, the finer the yarn, the greater the number of weak places. The danger here is that the weak places reach a critical level where a yarn break can occur (Fig. 24).

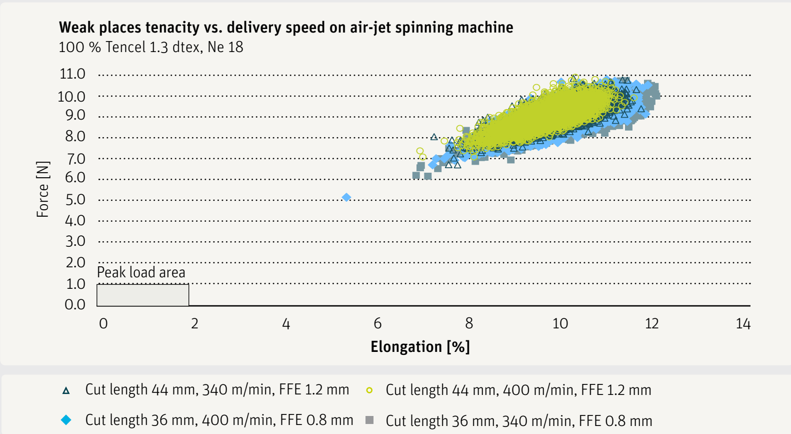

Fig. 25 Weak places

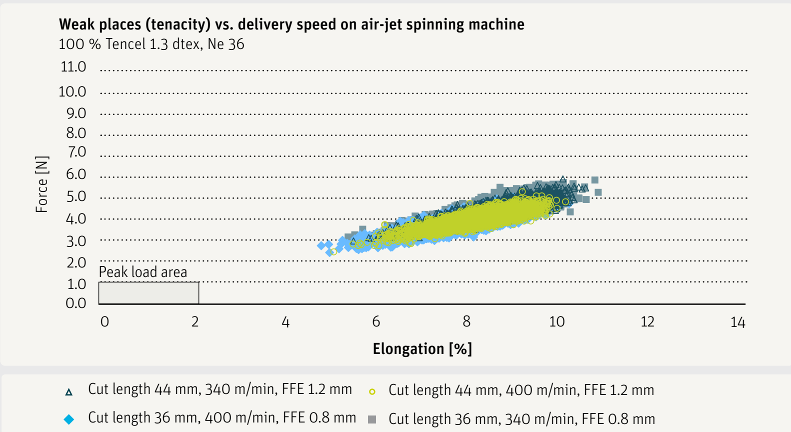

Fig. 26 Weak places

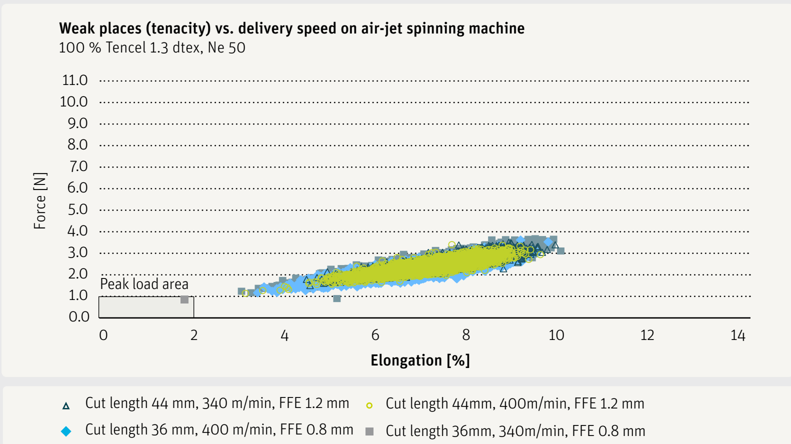

Fig. 27 Weak places

The tenacity/elongation profile displays a smaller variation for the longer fibers (44 mm) than for the 36 mm staple length. Furthermore, the variance of finer yarns increases irrespective of fiber length, and mean tenacity and elongation values decline (Fig. 25).

The values thus come ever closer to the critical range in which yarn breaks can occur in downstream processing of the yarn (Fig. 26).

The number of fibers in the cross-section is around 90 in a yarn count of Ne 50 and a fiber fineness of 1.3 dtex. It is estimated that the limit for final spinning is reached at a yarn count of approx. Ne 60, i.e. 75 fibers in the cross-section (Fig. 27).

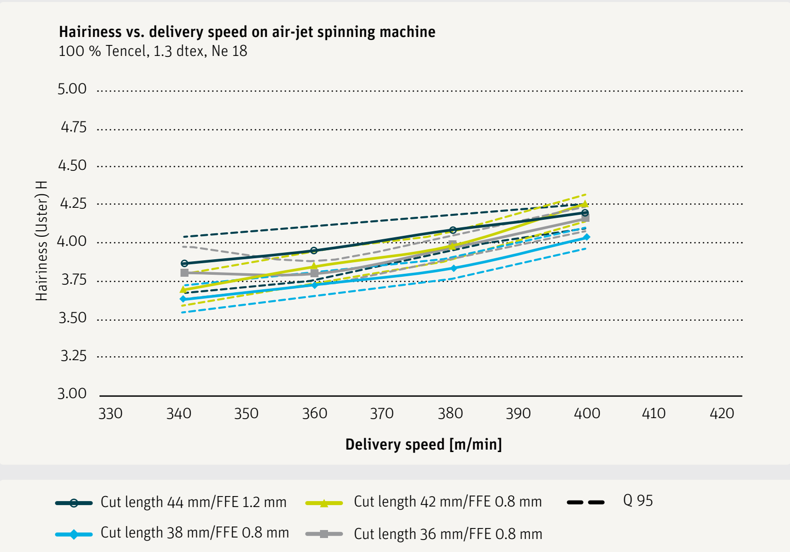

Fig. 28 Hairiness

Fig. 29 Hairiness

Hairiness

With increasing cut staple length it could have been expected that this would result in reduced hairiness in the yarn. However, this cannot be confirmed. Longer cut fiber lengths of 42-44 mm result in minimally higher hairiness across all yarn counts than with cut staple lengths of 36-38 mm (Fig. 28).

As a consequence the fabric hand in knitwear could be somewhat softer with longer fibers. However, this is not the case, as it emerged from the subsequent assessment of a knitted fabric. That is to say, the knitted fabric displayed a softer hand with shorter fiber lengths.

Besides staple length, yarn hairiness is also very dependent on fiber control between the delivery cylinder nip at the entry to the fiber feed element (FFE) and the fiber feed element to the spinning tip (see Fig. 29).To this extent a longer cut staple does not have to result in lower hairiness in every case in air-jet spinning, since this also depends on fiber control and integration.

It must also be borne in mind that in air-jet-spun yarns hairiness is very low compared to ring-spun or rotor-spun yarn. Somewhat greater hairiness in air-jet-spun yarn can therefore also be an advantage in a textile fabric structure.

It is important that an increase in hairiness for the given or same yarn tenacity is an advantage for further processing of yarn.

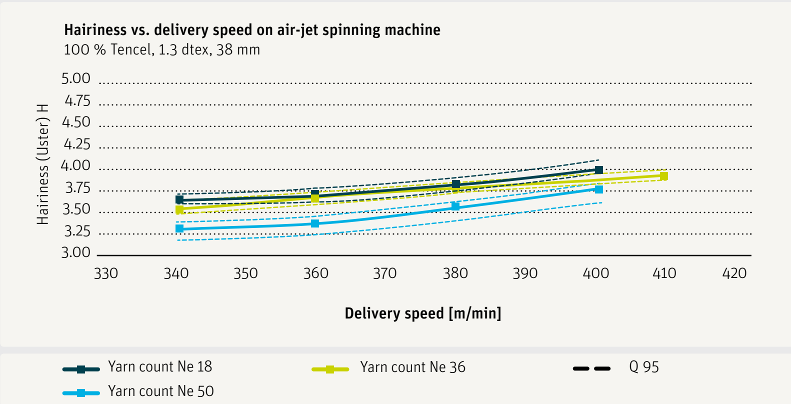

Fig. 30 Hairiness

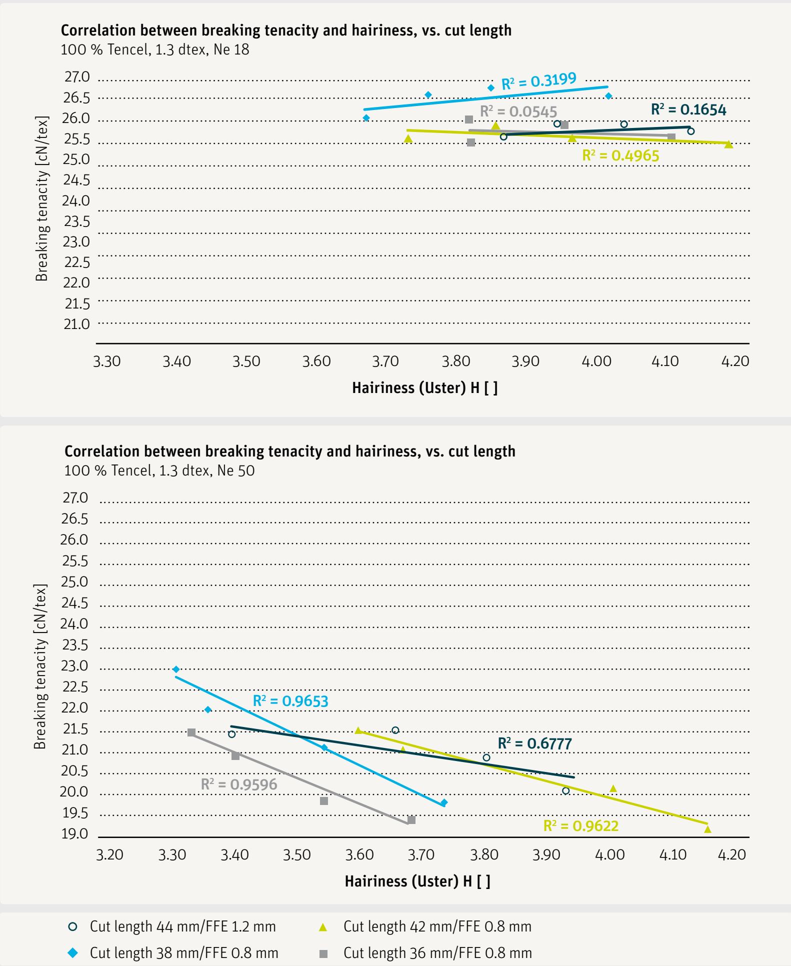

Fig. 31, 32 Correlation between yarn tenacity and hairiness

Delivery speed displays a much more significant influence on hairiness. With increasing delivery speed hairiness increases significantly; this is attributable to the change in yarn twist, i.e. the formation of the wrapping fibers.

The larger the number of fibers in the cross-section, i.e. the coarser the yarn with the same twist, the greater the hairiness due to the higher number of fibers around the surface of the yarn (Fig. 30). A coarser yarn will therefore always display greater hairiness. This applies to ring-spun, rotor-spun and also air-jet-spun yarns.

On the basis of the influences listed, a correlation exists between yarn tenacity and hairiness in a finer yarn. This is the case as soon as influencing factors such as twist changes or selection of technology components are greater than the influence of yarn mass.

That is to say, as long as the yarn count is relatively coarse, such as Ne 18, and there is thus no loss of tenacity with increasing delivery speed, there is also virtually no correlation between tenacity and hairiness (Fig. 31).

However, as soon as yarns become finer, as with Ne 36 and Ne 50, a corresponding correlation exists between tenacity and hairiness (Fig. 32).

Yarn structure

Yarn twist
Absolute yarn twist in an air-jet-spun yarn cannot be measured using the conventional twist measuring method due to its structure of wrapping fibers and core fibers.

The yarn was therefore untwisted under a microscope over a gauge length of 20 mm until the wrapping fibers were as parallel as possible with the axis of the yarn. However, this involves a certain degree of inaccuracy, since not all wrapping fibers cover the yarn core exactly and uniformly and therefore also cannot be precisely untwisted (Fig. 33).

The measuring method enables the absolute yarn twist of the wrapping fibers to be defined. However, it should not be forgotten here that the twist in air-jet yarn relates only to the wrapping fibers. It should be understood that the twist and twist factor of the air-jet yarn does not influence the yarn tenacity to the same degree as with ring yarn.

No differences in yarn twist were apparent between the individual cut staple lengths. In order to make the definition of yarn twist, i.e. of the measuring methodology, more informative, the mean value of the different fiber lengths was therefore calculated.

The measured twist does not indicate the effect of delivery speed for each yarn count due to the measuring problems already described. In a coarser yarn (Ne 18) the effect of delivery speed on yarn twist was not apparent. However, in finer yarns (Ne 36, Ne 50) the reduction in yarn twist with rising delivery speeds on the air-jet spinning machine was clearly apparent (Fig. 34).

The reduction in twist also results in a change in yarn structure. To this extent certain structures in the form of neps can be detected during yarn regularity measurement, depending on yarn count.

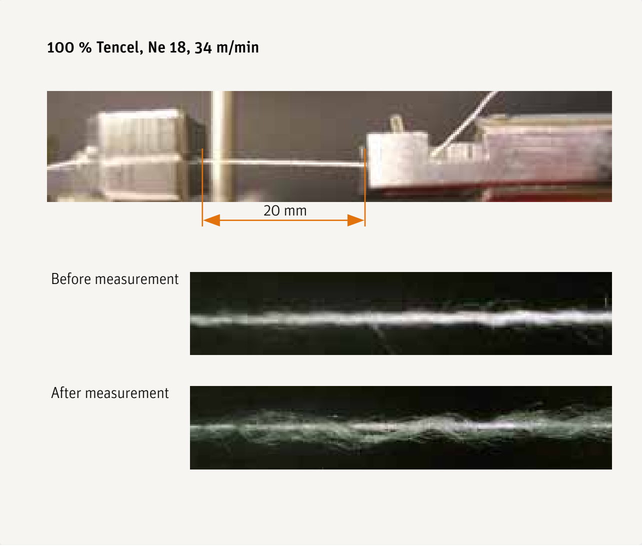

Fig. 33 Microscopic measuring method

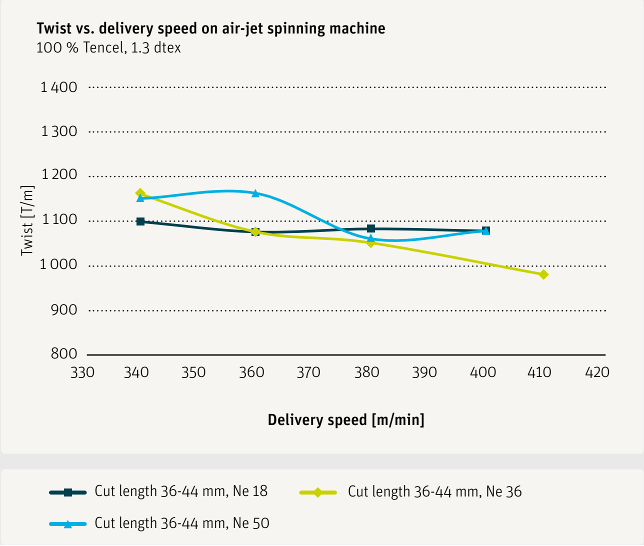

Fig. 34 Twist

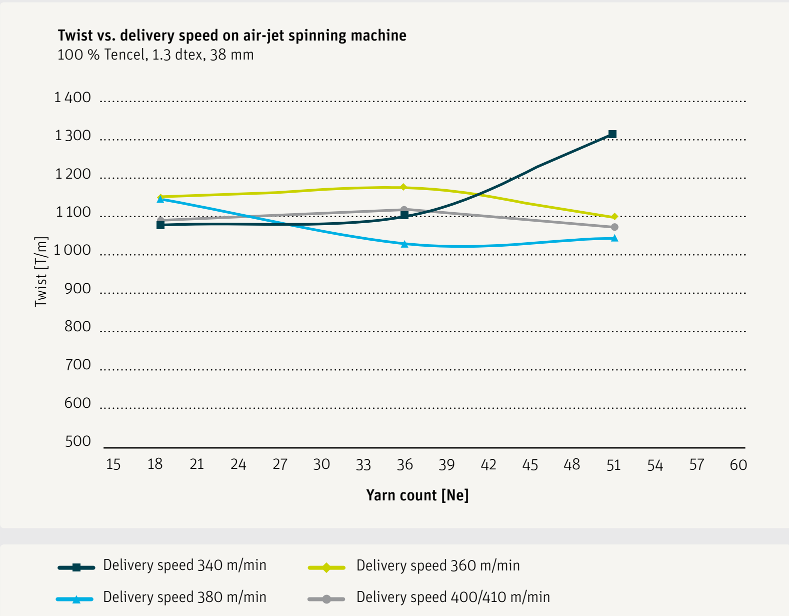

Fig. 35 Yarn twist

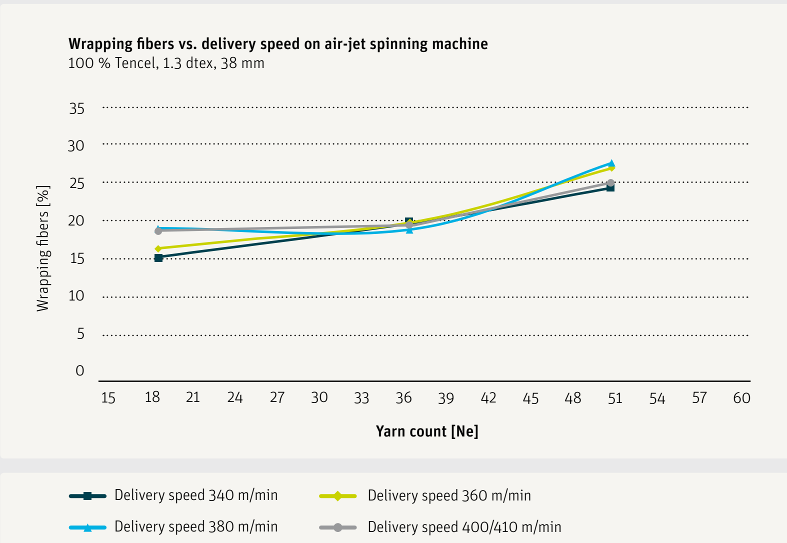

Fig. 36 Proportion of wrapping fibers

Yarn twist is not influenced– or at least not significantly – by yarn count. The reason for this is presumably that virtually the same energy is expended to twist the wrapping fibers regardless of yarn count. The number of yarn twists per unit of length is thus constant, regardless of yarn count (Fig. 35).

Yarn twist is affected by:

- higher delivery speeds, at which yarn twist declines,
- spinning pressure and flow conditions, i.e. fiber sun speed,
- friction conditions in the spinning chamber between the fibers and technology components, such as surface and shape.

Yarn twist is not affected by:

- fiber staple length
- yarn count (no significant effect)

The following equation thus applies at least:

$$\alpha_m \approx \frac{1}{V}$$

V = delivery speed

Proportion of wrapping fibers

No clear influence of cut staple length on the proportion of wrapping fibers is apparent. Despite variance, a minimal increase in wrapping fibers is apparent with increasing delivery speed.

The relative proportion of wrapping fibers is primarily dependent on yarn count. If the absolute number of wrapping fibers remains constant over yarn count, the relative proportion of wrapping fibers must increase with finer yarn. For example, the proportion of wrapping fibers is approx. 17 % in an Ne 18 yarn count and approx. 25 % in an Ne 50 yarn count (Fig. 36). We know

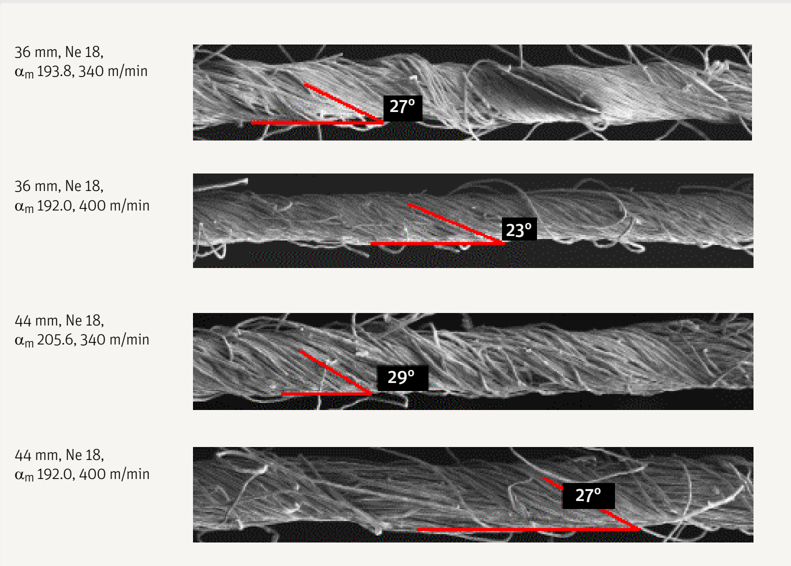

Fig. 37 Yarn twist angle

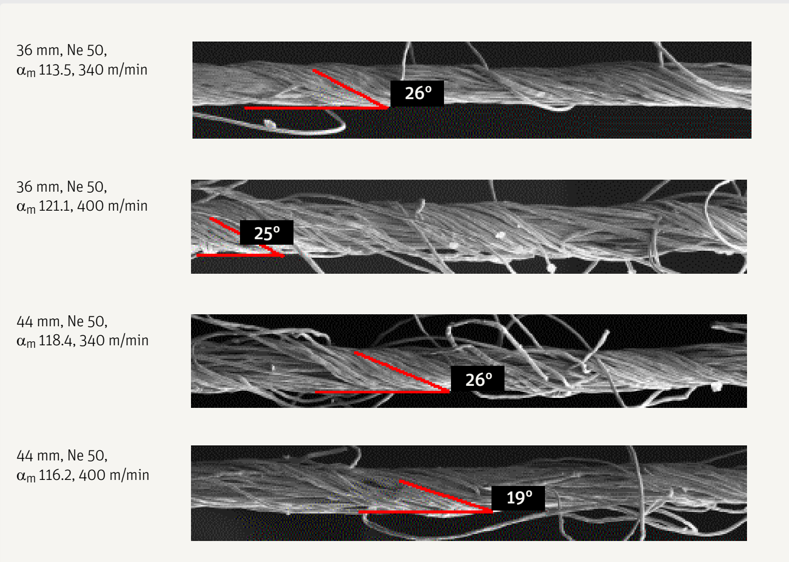

Fig. 38 Yarn twist angle

from numerous studies already conducted that the fiber bundle in the FFE is bulkier due to lower spinning tension. This enables the outer fibers to be formed more easily to wrapping fibers when the fiber balloon speed is subsequently imparted than in the case of a compact fiber bundle, i.e. high spinning draft.
The wrapping fiber therefore depends primarily on the following parameters:

- yarn count
- delivery speed
- spinning draft

Yarn twist angle

The short length of yarn means that visual assessment using a microscope does not enable a complete assessment of the yarn structure between the different cut staples to be made. The yarn twist angle of the wrapping fibers at the different delivery speeds is shown in Fig. 37 and 38.

The angle becomes smaller with increasing delivery speed, e.g. from 340 m/min to 400 m/min. A small yarn twist angle with increasing delivery speed is therefore equivalent to a reduction in yarn twist.

The yarn twist angle differs visually here and not between the different yarn counts, which has already been confirmed on the basis of the twist measurement.

Yarn diameter
Yarn diameter with the same yarn count, i.e. yarn mass, describes the bulk which in turn influences the pile density, i.e. visual regularity in the final article.

Staple length has only negligible influence – on the yarn diameter of air-jet-spun yarns. A negligibly larger yarn diameter is apparent with longer cut staple only in very fine yarn, such as Ne 50.

Here again delivery speed has a clear influence on yarn diameter. Yarn diameter increases with increasing delivery speed. Findings to date also confirm that the compressive forces must affect yarn density and thus also yarn diameter (Fig. 39). The following equation therefore applies:

$$d \approx \frac{1}{\mathrm{Ne}}$$

$$d \approx V$$

V = delivery speed

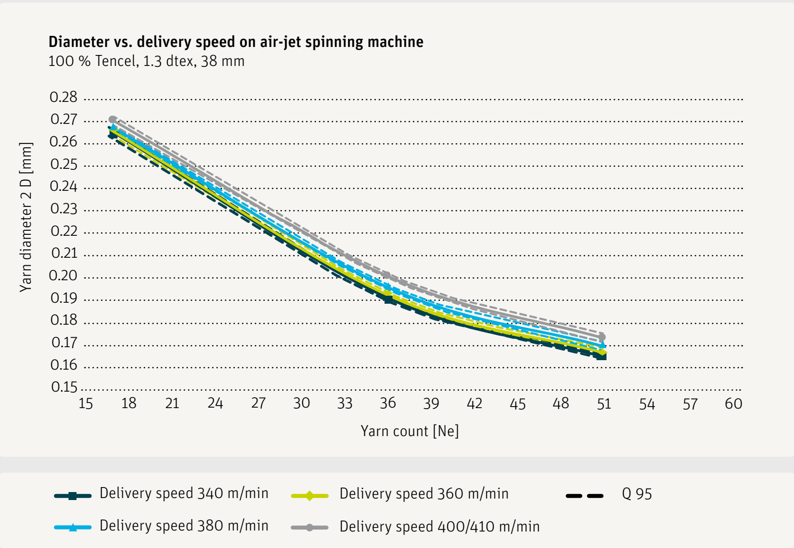

Fig. 39 Yarn diameter

Abrasion resistance (Webtester)

The abrasion resistance of the yarns is a further important criterion in subsequent stages of downstream processing of the yarn and for the serviceability properties of the textile fabrics. The resistance of the yarns to a specified number of abrasion cycles on the yarn bundle was measured by means of the Reutlingen Webtester for this purpose. This measuring method enables, for example, the resistance of the yarns when used as warp ends in weaving to be simulated. However, the measured values are also an excellent criterion of the precision of fiber integration in the yarn. It can be assumed here that an abrasion-resistant yarn offers advantages not only in the weaving process, but at all downstream processing stages as far as the properties of the textile fabric (Fig. 40).

It should be noted here 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 studies of air-jet-spun yarns show that yarn count and delivery speed have a significant influence on the maximum achievable number of abrasion cycles.

The coarser the yarn and the lower the delivery speed, the higher the maximum achievable number of abrasion cycles before the yarn is permanently deformed. The reason for this effect is that the smaller yarn twist angle reduces the frictional forces between the fibers as delivery speed increases. However, since fiber strength of approx. 37 cN/tex is very high and the fibers are very long with a cut staple length of 38-44 mm, plastic deformation, i.e. extension of the yarn, occurs rather than breakage (Fig. 41).

The fewer fibers present in the cross-section, the greater the reduction in mutual frictional forces. The yarns display plastic deformation sooner, i.e. the number of abrasion cycles declines. The results show that the number of abrasion cycles can be changed by the yarn twist angle (delivery speed) and the relative proportion of wrapping fibers (yarn count).

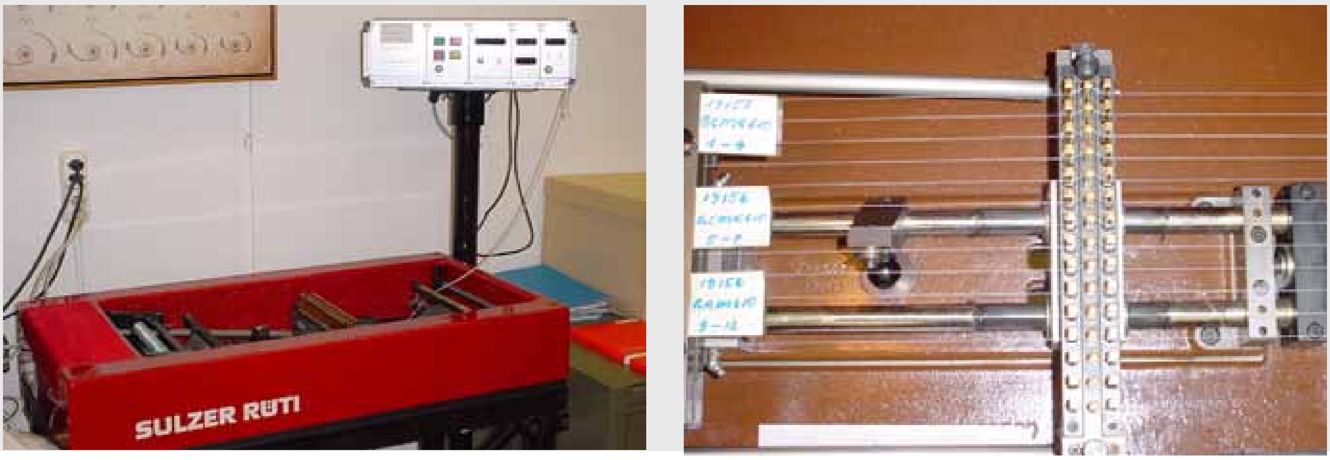

Fig. 40 Reutlingen Webtester

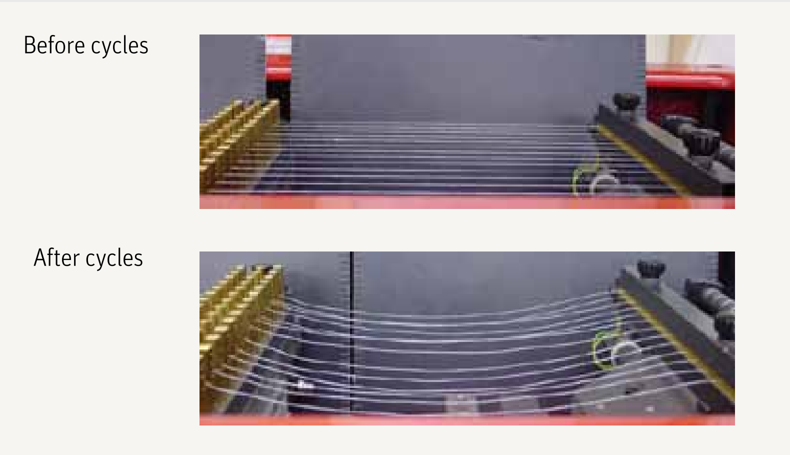

Fig 41 Plastic deformation of the yarn

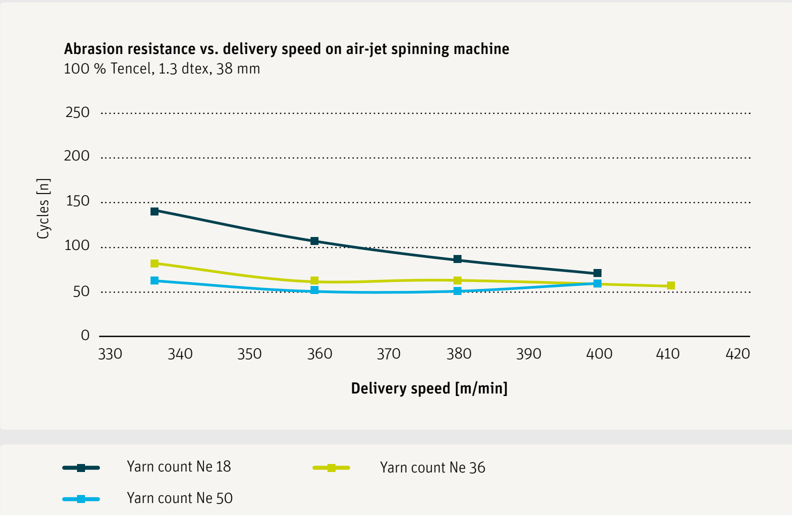

Fig. 42 Abrasion resistance

The following relationships can be established for the yarn integration angle:

- the lesser the yarn twist angle and the larger the relative proportion of wrapping fibers, the sooner the yarn is deformed under mechanical stress,
- the lesser the yarn twist angle, the softer the hand of the knitted fabric; the yarn tenacity requirements in knitting are not very high, so that a high delivery speed can be used for knitting applications, while lower speeds should be used in weaving.

The number of wrapping fibers increases in a finer yarn. This should have a positive impact on fiber/fiber friction, but the influence of the number of fibers in the cross-section is much greater than the effect of wrapping fiber numbers.

Plastic deformation (EP) under tension and abrasion stress is therefore inversely proportional:

- to the yarn twist angle (β),
- to the number of fibers in the cross-section (AQ) and
- to the number of wrapping fibers (UF_R)

No influence of fiber cut staple length on the number of abrasion cycles could be established.

In order to increase the proportion of wrapping fibers with a constant number of fibers in the cross-section, a higher fiber sun speed would have to be applied.

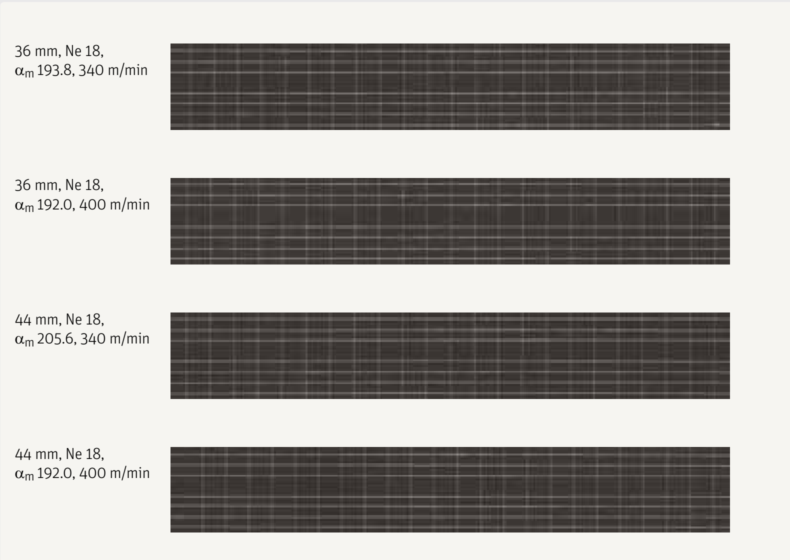

Fig. 43 Fiber shifting

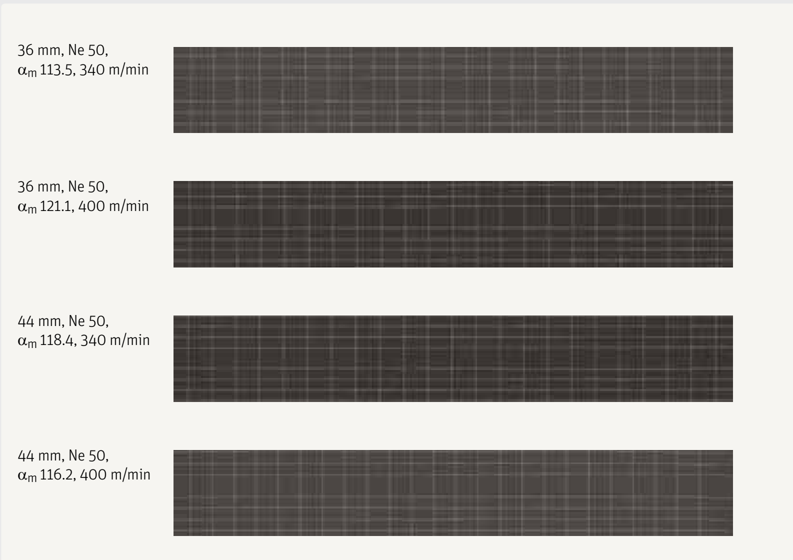

Fig. 44 Fiber shifting

Therefore:

$$EP \approx \frac{1}{\beta \text{ x } AQ \text{ x } UF_R}$$

where EP = 1/n turns

Plastic deformation under tension and abrasion stress on the yarn must be counteracted by selecting the correct spinning elements and settings, depending on downstream processing requirements for the yarn.

The study was also intended to point out the physical limits and relationships. Only in this way is it possible to use the yarns selectively and appropriately in downstream processing. For example, if air-jet-spun yarns are used as warp ends in weaving, yarn elasticity which is too low can result in problems. The impact on service-ability properties in the finished textile product, for example after a certain number of washing cycles, must also be taken into consideration here.

If plastic deformation under excessive stress is too high, the final article can display too little dimensional stability. This effect can make itself unfavorably apparent in «bagging» of the fabric when the final article is used under severe stress. The delivery speed on the air-jet spinning machine should be reduced in order to counteract this effect.

The study shows that yarns which record a lower number of abrasion cycles (e.g. Ne 50) undergo plastic deformation more quickly under stress (Fig. 42).

End Spinning Process	Air-jet spinning	Ring spinning
Number of spinning units	100	1 632
Delivery speed [m/min]		
Ne 18	340-400	21.1
Ne 36	340-400	20.9
Ne 50	340-400	18.5
Raw Material	100 % Tencel®	
Spinning process	Blowroom Card 3 Draw frame passes -	Blowroom Card 2 Draw frame passes Roving frame
Size of Plant	960 kg/h	950 kg/h
Location	Indonesia	

Fig. 45 Trial setup

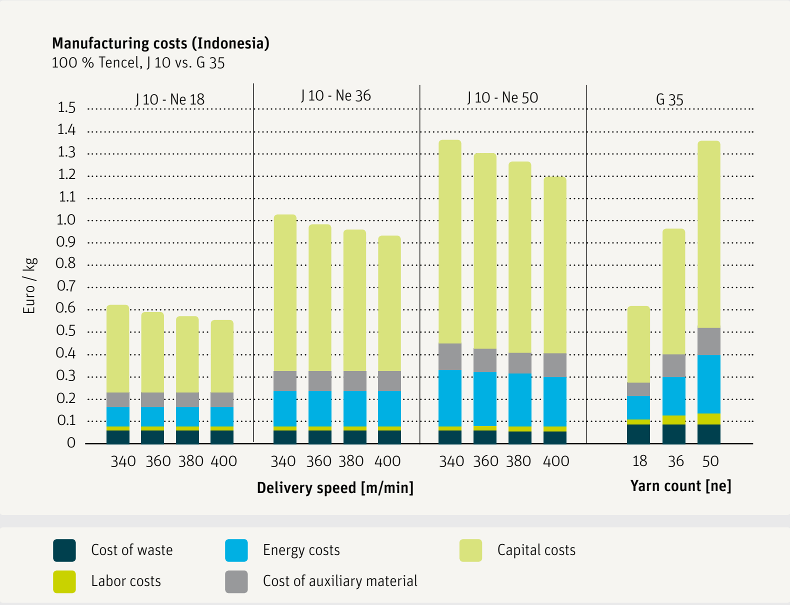

Fig. 46 Yarn manufacturing costs: air-jet-spun yarn vs. ring-spun yarn

After ascertaining the maximum number of abrasion cycles until shortly before fiber breakage, visual appearance with regard to fiber «abrasion» must also be observed. This finding has repeatedly become apparent to date when using air-jet-spun yarns. The yarn structure is very abrasion-resistant, which is also evident in the exceptionally good pilling values of the textile product.

This shows that virtually no fiber abrasion occurs in air-jet-spun yarns (Fig. 43/44).

Yarn manufacturing costs

The finer the air-jet-spun yarn, the greater the advantages of higher delivery speeds for yarn manufacturing costs.

Due to the high capital costs of air-jet spinning technology, yarn manufacturing costs for a yarn count of Ne 50 are € 1.35 and therefore at the same level as those of a ring-spun yarn. Yarn manufacturing costs for an air-jet-spun yarn used in knitting and the associated higher delivery speed of 400 m/min are 10 % lower than for a ring-spun yarn (Fig. 45/46).

Summary

TENCEL® fibers in 36 and 38 mm staple lengths can be processed very satisfactorily on the C 60 card with nep reduction of 90 % and minimal fiber stress with only 10 % strength loss.

The fiber length of 38 mm displays the best values for the incidence of neps over the spinning process.

No clear trends or differences are apparent with regard to irregularity and thin and thick places up to a yarn count of Ne 36. Only with a finer yarn, such as Ne 50, can better regularity results and a lower number of thin and thick places be achieved with increasing cut staple length.

A longer cut staple length has no general advantages in tenacity with yarns in the Ne 18 and Ne 36 range. However, greater yarn elongation is observed in finer yarns.

No clear impact of cut staple length on the proportion of wrapping fibers is to be observed. With regard to the relative number of wrapping fibers there is a clear dependence on fiber mass, i.e. fiber fineness. The number of wrapping fibers increases with finer yarn. For example, wrapping fiber proportions of approx. 17 % and 25 % are recorded with yarn counts of Ne 18 and Ne 50, respectively.

Yarn tenacity, hairiness and elongation are clearly affected by delivery speed on the air-jet spinning machine, depending on yarn count. Depending on the sphere of application of the yarn, the optimal delivery speed must therefore be established. The higher the delivery speed, the softer the hand but the lower the yarn tenacity and elongation.

The limit to the number of fibers in the cross-section is soon reached at a yarn count of Ne 50 with a fiber fineness of 1.3 dtex. It is estimated that the final spinning limit is reached with a yarn count of approx. Ne 60, i.e. 75 fibers in the cross-section.

Air-jet-spun yarn displays no abrasion on the yarn bundle under abrasion stress. This favorable effect of air-jet-spun yarn has already been pointed out a number of times in various studies (refer also to Rieter offprint No. 2218). These advantages are independent of fiber length and are determined only by the yarn structure.

Technology components of the air-jet spinning machine
The selection of technology components listed below enable the optimal settings to be found, depending on application, raw material and yarn count (Fig. 47).

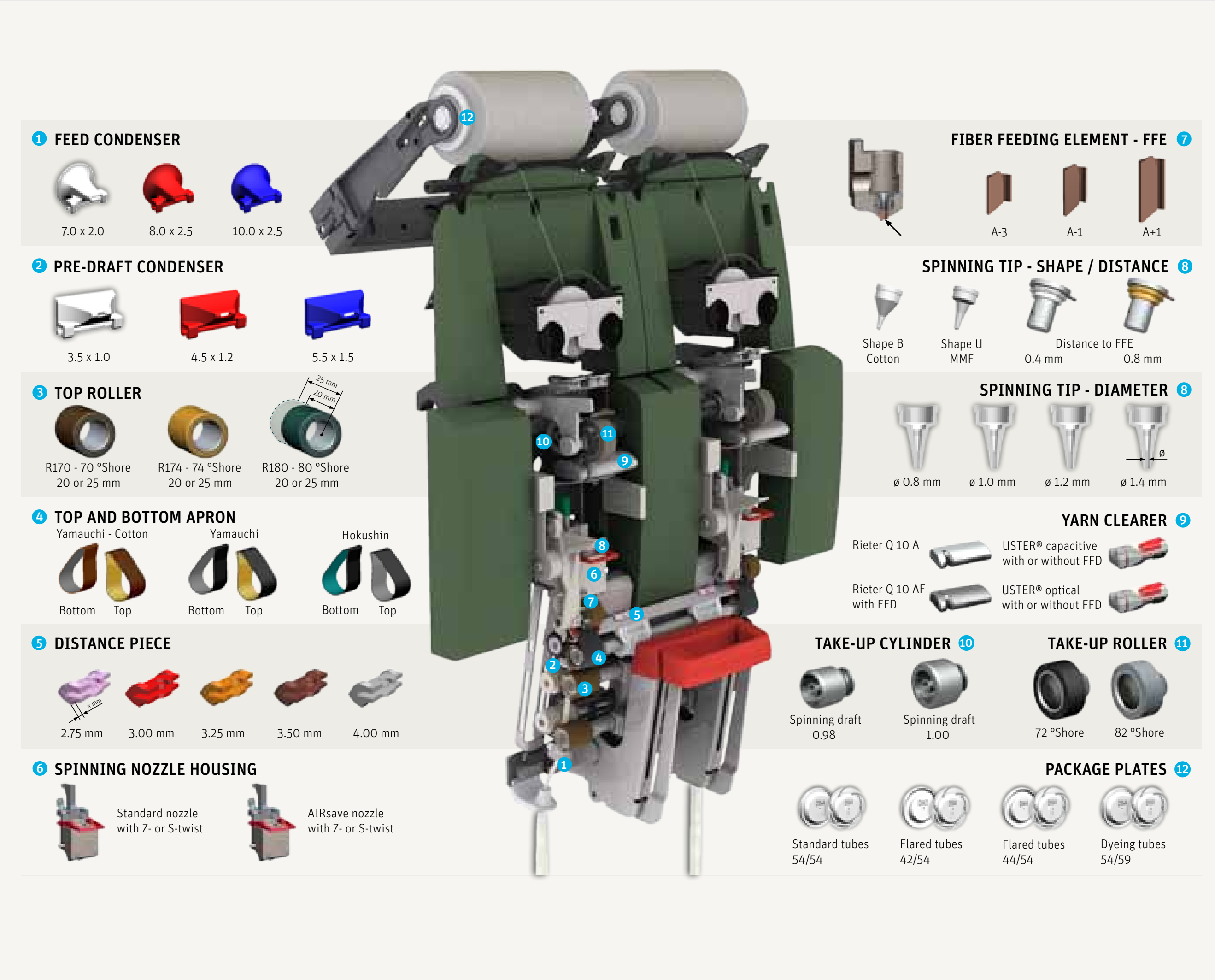

Fig. 47 Technology components

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