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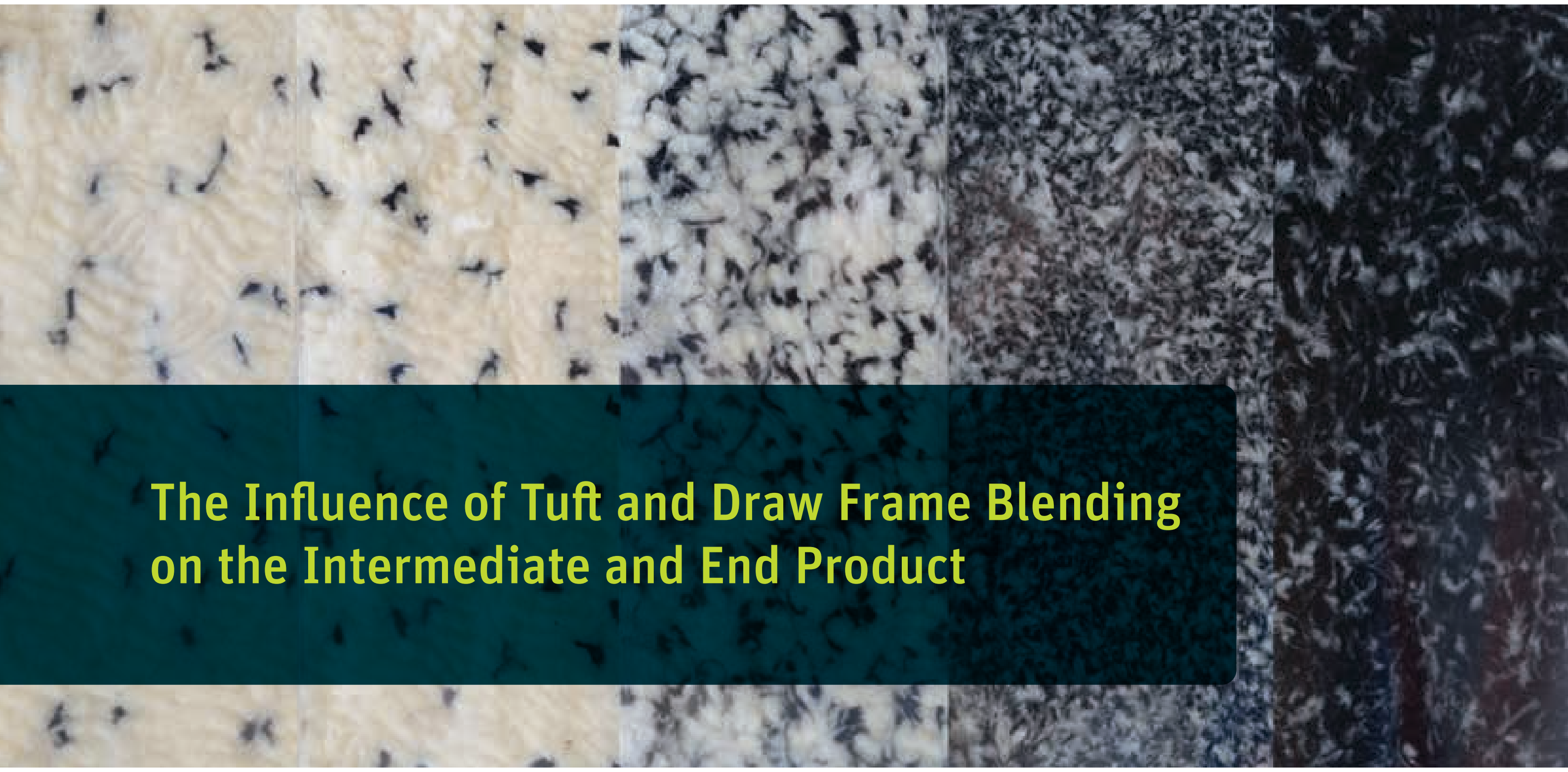
June 2022



The Influence of Tuft and Draw Frame Blending on the Intermediate and End Product

Contents

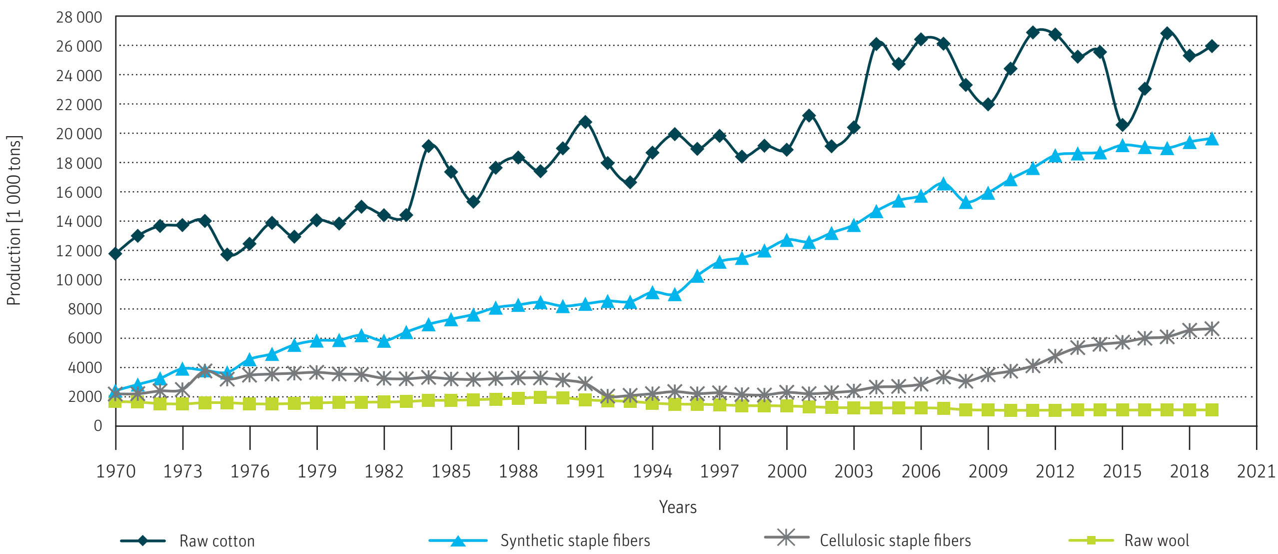
1. Blends in the Short-Staple Fiber Production

As population growth and prosperity increase, so does the consumption of fibers across the globe. While this holds true for all staple fibers, the production of man-made fibers such as cellulosic staple fibers and synthetic staple fibers is growing particularly quickly (Fig. 1).

Estimates assume that 45% of the fibers will be processed in their pure state. 55% will be spun to blended yarns. The mix of cotton with polyester dominates the blended yarn range with almost 50%.
Blended yarns are so appealing because the yarn properties can be specifically influenced through the combination of fibers made of different raw materials or of varying length or fineness.

A business shirt has different requirements in terms of yarn than a pair of hiking pants or a sports shirt. Garments made of blends can have functionalities like improved moisture removal or water vapor permeability, a lower tendency to wrinkle, higher wash resistance and wear comfort.

Staple Fiber Production Worldwide



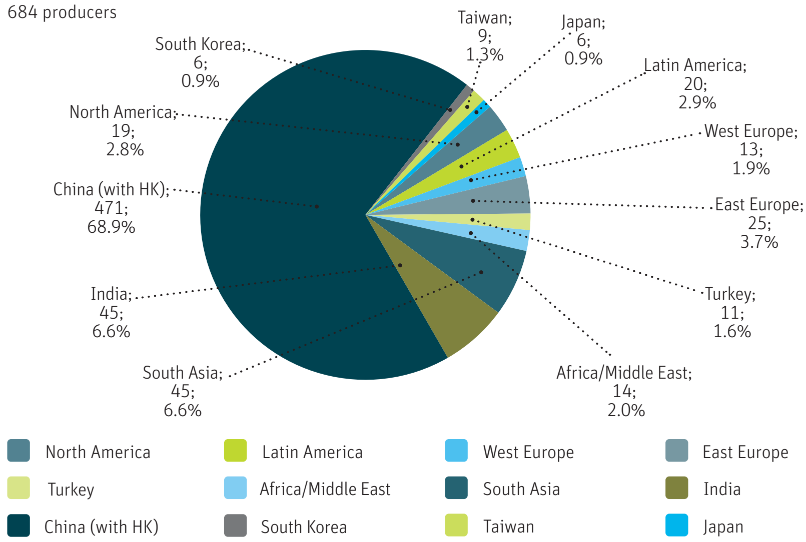
Source: CIRFS 2020, Technology RMS-ETP

Fig. 1: The production of man-made fibers is increasing quickly.

China supplies 57% of the world's synthetic staple fibers for the global market. This circumstance leads to the fact that China also tops the list of polyester manufacturers (Fig. 2).

Polyester Staple Fiber Producers World 2020

684 producers



Source: Wood Mackenzie 2020, Analysis RMS-ETP

Fig. 2: 68.9% of all polyester staple fiber producers are located in China.

2. Objective of the Investigation

Due to the increasing consumption of man-made fibers and the important role of blends, Rieter has carried out an investigation on the topic of cotton-polyester blends. Blending can be defined as the process of combining fibers of different raw materials, length, thickness, or color to make yarn. Blending can take place at different stages of the spinning process. In this investigation two common blending systems were compared: Firstly, the tuft blending through continuous mass feeding in fiber preparation via the precision blender UNIblend and secondly the sliver blending by blending the card sliver of each raw material component on a draw frame. The objective was to find out how the homogeneity of the yarn and fabric is influenced by the blending system, the blending proportion, and the end-spinning process (ring or rotor). Based on different quality criteria, a guideline was developed as to when which blending system is recommended by Rieter.

3. Definitions

3.1. Homogeneity

The present investigation is intended to compare the homogeneity of the tuft blend and the draw frame blend. Homogeneity (H) is essentially determined by two factors: the constant fiber mass of each raw material component over time (M) and the way of blending (B). In simplified terms, homogeneity is composed of the variables M and B:

$H = M + B$

The constant feeding of the fiber mass of each raw material component over the time (M) is determined by the machine design or by different mixing possibilities such as, for example

- a continuously precisely metered mass feed (UNIblend),
- or a discontinuous mass feeding (weighing systems)
- or by means of process stages for fiber orientation and evenness (draw frame passages).

Further influences (B) result from the different ways of blending:

- Process sequence and combination of process stages
- Amount of process stages
- Technology components
- Machinery setting
- End-spinning system

3.2. Homogeneity over time through continuous mass feeding

The UNIblend ensures continuous mass feeding [g/cm x min] by keeping the tuft density [g/cm^3] constant. This constancy can be delivered by adapting the distance A [cm] between the feed cylinders to the volume of the respective fiber mass. The feed cylinders thus control the feed speed L [cm/min] which leads to a continuous fiber mass feed of the respective raw material component.

According to the operating principle, the following technological relationship can thus be described mathematically:

$$M = D_E \times L \times A \; \frac{g}{[cm \times min]}$$

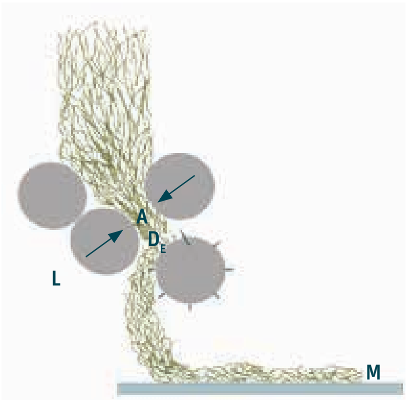


Fig. 3: Homogeneity over time through continuous and constant mass feeding

D_E = Flock density [g/cm^3]
L = Speed variable [cm/min]
A = Distance between delivery rollers [cm]
g = Fiber weight

$D_E = D_F \times C$
D_F = Fiber density [g/cm^3]
C = Factor = 0.7

4. Trial Overview

4.1. Raw material

Since polyester-cotton blends are common in the market, this blend was chosen for the trial. A medium cotton quality and a black spun-dyed polyester served as raw materials. Thanks to the color difference, the blending behavior could thus be better assessed already at the beginning of the process stages.

	Cotton	Polyester
Type		Black spun-dyed
Fiber length	1 1/8“	38,0 mm
Mean fiber length	21 mm	30,4 mm
Short fiber < 12,5mm	19%	2%
Fiber finesse Mic.	4,65 [µg/ inch]	1,7 dtex
Fiber tenacity	22.9 cN/ tex	51 cN / tex
Fiber elongation	9.8%	25.6%

4.2. Process tuft blending

The following processes were used to produce ring and rotor yarns with tuft blending. The UNIblend ensures continuous mass feeding by keeping the tuft density constant and due to the variable delivery speed.

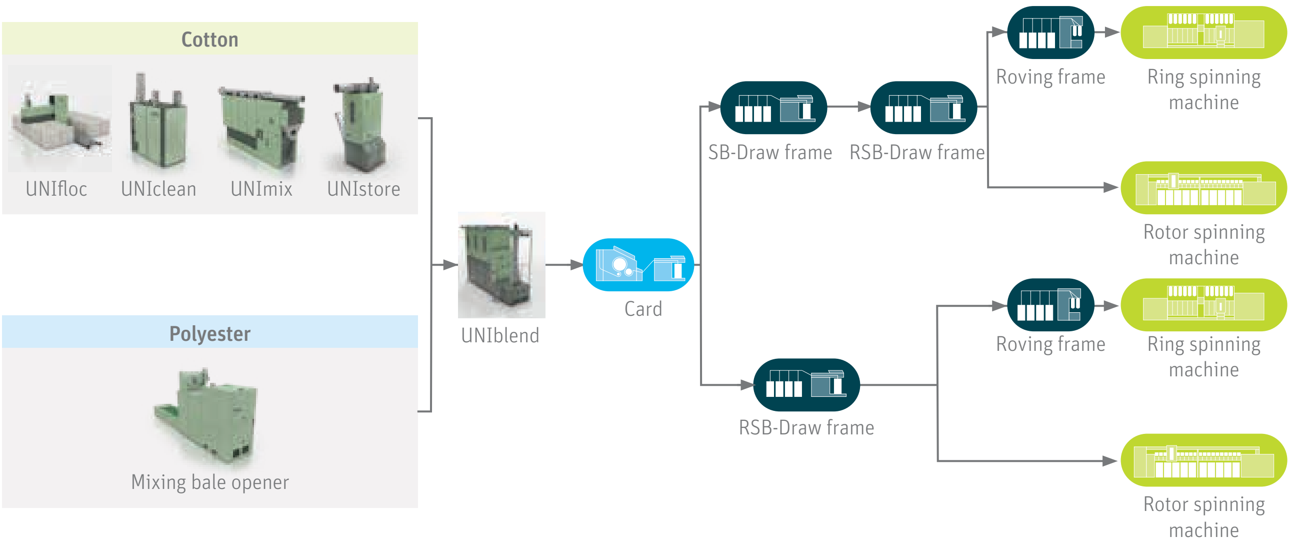


Fig. 4: Process tuft blend

4.3. Process draw frame blending

The processes listed below were used for the draw frame blends. To open the polyester, the mixing bale opener with an opening position was used. The blending draw frame was fed with card sliver of each raw material component. Afterwards one or two draw frames followed.

If the blend ratio cannot be achieved with the number of slivers available, the card slivers must be manufactured in varying counts. This mostly means an additional logistical effort in the carding sector. With a 30-50% share of a blending component, the logistical organization for the blending process is minimal and unproblematic.

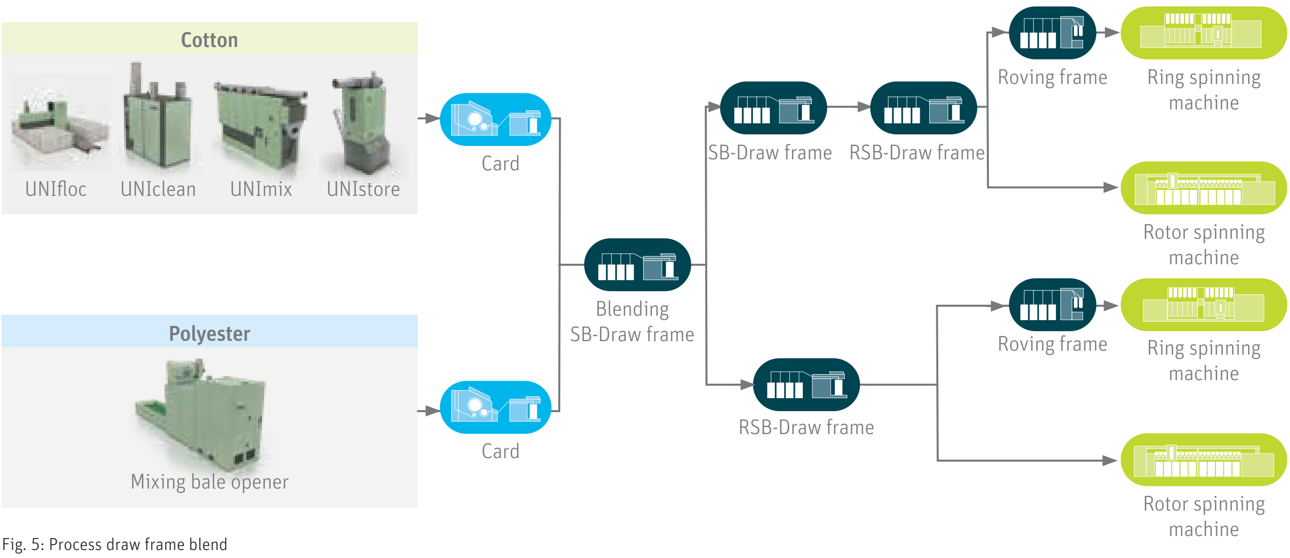


Fig. 5: Process draw frame blend

4.4. Blend rations

Five different polyester-cotton blend ratios were produced, and each processed as tuft and draw frame blend. The choice of card clothing and the settings with both types of raw material were left constant in order to be able to show the influence of the blending systems.

Polyester (%)	Cotton (%)
2	98
5	95
20	80
33	67
67	33

5. Results in Sliver and Roving

After the trials had been carried out, the composition of the intermediate products (sliver and roving) were examined.

5.1. Fiber length utilization in the sliver

In order to more thoroughly examine the influence on evenness and fiber alignment in the fiber package, the fiber length utilization was determined in the drafted sliver. The fiber length utilization is an indicator for the parallel position as well as for the regularity in the the fiber strand. This examination took place with the Parallex from Litty by cutting a piece of defined length, clamp it in the middle and comb out the fibers on the right and on the left (Fig. 6). Based on the weight determination of the fibers which are combed out and the waste, the fiber length utilization is calculated in millimeters. The more tangled and less parallel the fibers are, the smaller the fiber length utilization will be.

The results showed that the sliver from the draw frame blend clearly had less tangled fibers and more parallel fibers incorporated in the web compared to the sliver from the tuft blend (Fig. 7).

Before combing	**After combing**	**Waste**
Sample length = L1 [mm]	Fiber length utilization = Lx [mm]	Weight
Weight before = G [mg]	Weight after = GK [mg]	Noil = A [mg]

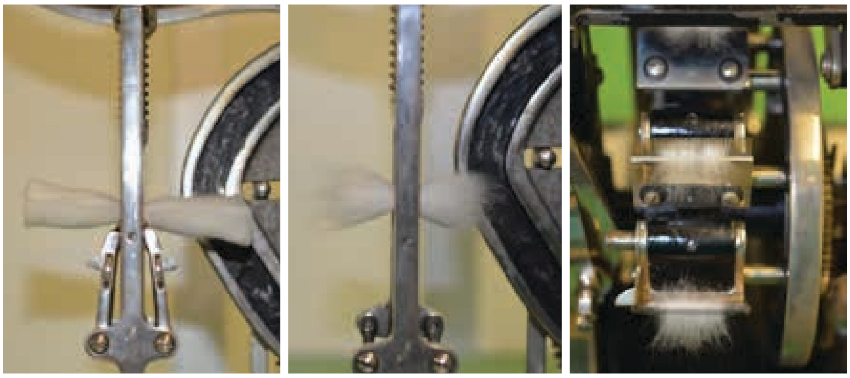


Fig. 6: The "fiber length utilization" of the slivers was measured with the Parallex from Litty.

$$\frac{LX.[mm]}{GK.[mg]} = \frac{L1.[mm]}{G.[mg]}$$

$$Lx.[mm] = \left(\frac{L1.[mm]}{GK.[mg] + A.\,[mg]}\right) x\; GK.[mg]$$

Lx = Fiber length utilization [mm]
A = Weight of noil [mg]
GK = Weight of combed fibers in fiber strand [mg]
L1 = Sample length [mm]
G = Weight of fibers in sample length [mg]

Fiber length utilization versus polyester content
Polyester, 1.7 dtex, 38 mm, Cotton, 1 1/8", Mic. 4.65, 5 900 tex

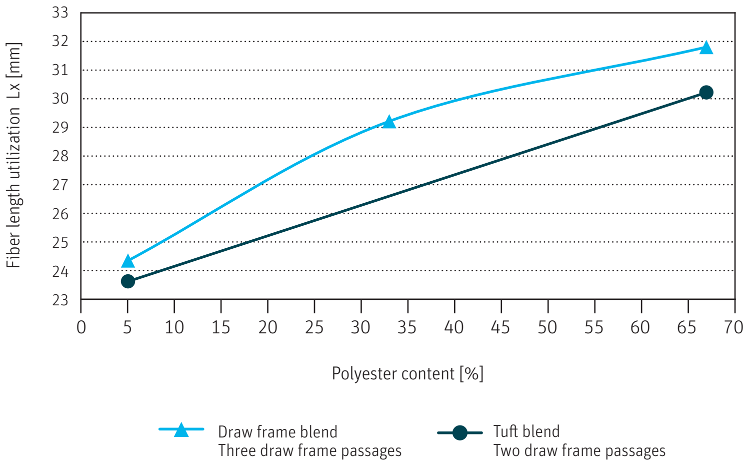


Fig. 7: The draw frame blend has more long, and parallel fibers incorporated in the web.

Source: Technology & Process Analytics, TIS 19141

The first assumption is that this result occurs because the draw frame blend has one more draw frame in the process (the blending draw frame and two additional draw frames). To check if this is true, the result of the sliver was examined with only two draw frame passages and compared with the sliver from the tuft blend with two draw frame passages as before. So, the number of draw frame passages is effectively the same now. Nevertheless, the draw frame blend still shows a higher fiber length utilization (Fig. 8).

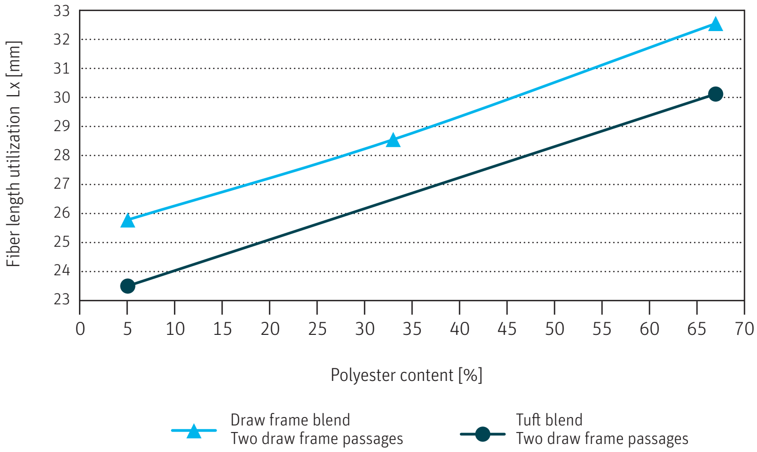
The reason for the higher fiber length utilization of the draw frame blend could be that the drafting forces presumably are higher than with the tuft blend. As long as no drafting faults occur, higher drafting forces have a higher parallelization effect. The effect is the same as when the cylinder distance is very closely set in relation to the fiber length. The polyester content also plays a role. It leads to a higher fiber length utilization.

The next graphic shows that the greatest increase of fiber length utilization takes place in the blending draw frame and the first following draw frame passage. The results with a polyester content of 67% show that the second following passage only has a minor additional influence on the fiber length utilization (Fig. 9).

This suggests that the number of draw frame passages alone doesn't determine the fiber length utilization. If these results are also reflected in the yarn will be shown later.

Fiber length utilization versus polyester content

Polyester, 1.7 dtex, 38 mm, cotton, 1 1/8", Mic.4.65, 5 900 tex

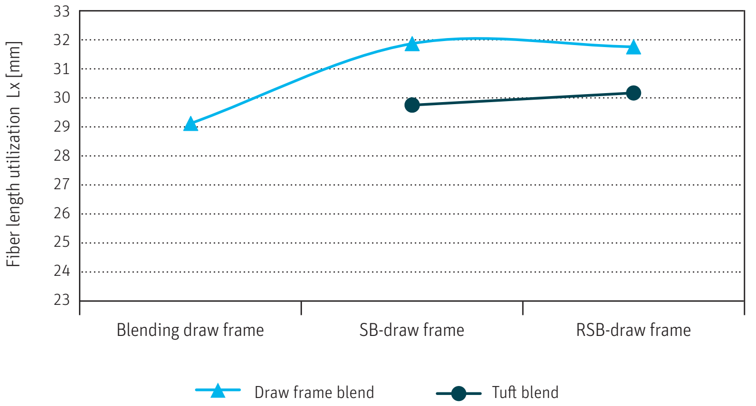


Source: Technology & Process Analytics, TIS 19141

Fig. 8: The draw frame blend shows a higher fiber length utilization also with the same number of passages.

Fiber length utilization versus process step

67% Polyester, 1.7 dtex, 38 mm/33% cotton, 1 1/8", Mic. 4.65, 5 900 tex



Source: Technology & Process Analytics, TIS 19141

Fig. 9: The greatest increase of fiber length utilization takes place in the blending draw frame.

5.2. Cohesive length in the sliver

A higher fiber length utilization and a lower cohesive length in the fiber package indicate that the irregularity in the draw frame sliver and the roving will be better. It is mostly a sign of better fiber parallelization and regularity. The effect must be traced back to the more intensive drafting work on the draw frames with the draw frame blend.

The polyester content has a great influence on evenness and cohesive length. With an increasing polyester content, a greater fiber-to-fiber friction results and, consequently, also a greater cohesive length in the sliver. This also means that in the drafting systems, greater drafting forces exists than with a lower polyester content (Fig. 10).

The fiber masses in the drafting system and the settings must therefore be selected, independent of the blending system, so that no drafting faults and consequently disadvantages in the running properties of the subsequent process stages and the yarn quality occur.

The cohesive length is not alone influenced by the number of draw frame passages. This is shown by these test series where two draw frame passages with both blending systems were used. Nevertheless, the draw frame blend shows a lower cohesive length - that is better parallelization - than the tuft blend (Fig. 11). Therefore, the number of draw frame passages cannot be the only influence on fiber parallelization.

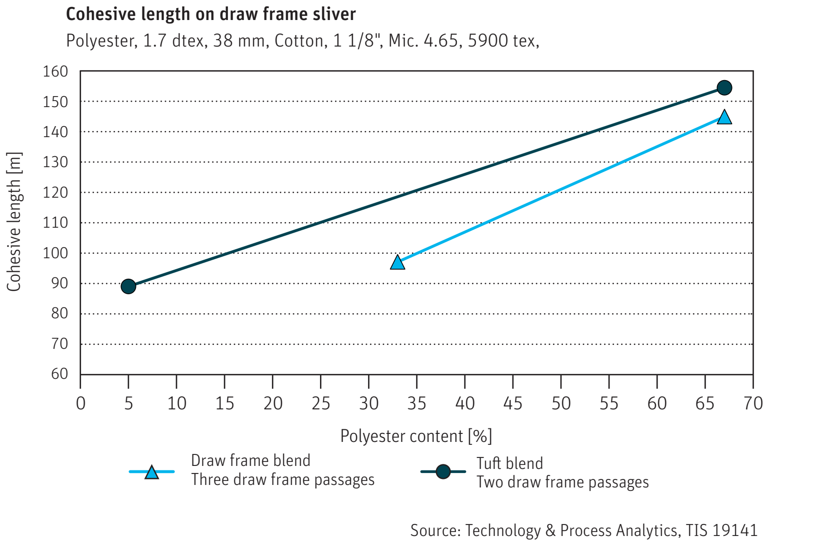


Fig. 10: With an increasing polyester content, a greater fiber-to-fiber friction results and, consequently, also a greater cohesive length in the sliver.

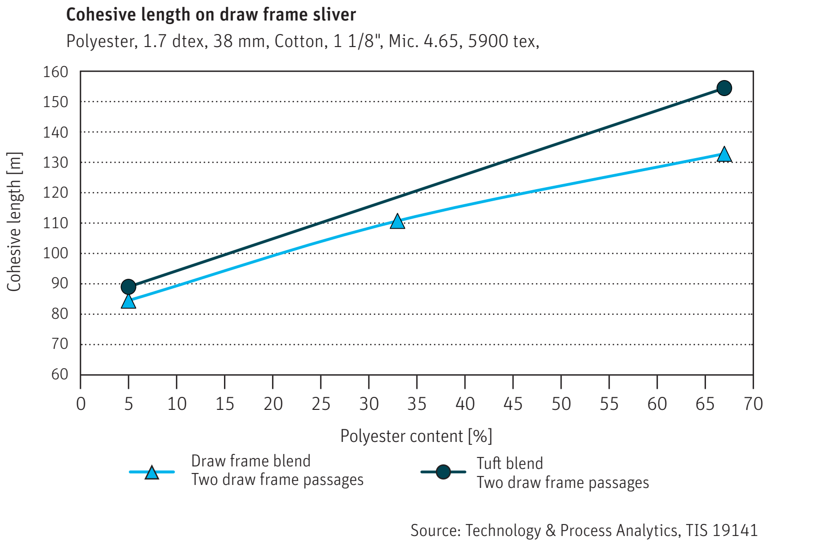


Fig. 11: The draw frame blend shows a lower cohesive length - that is better parallelization - than the tuft blend, also with the same number of draw frame passages.

5.3. Evenness in the roving

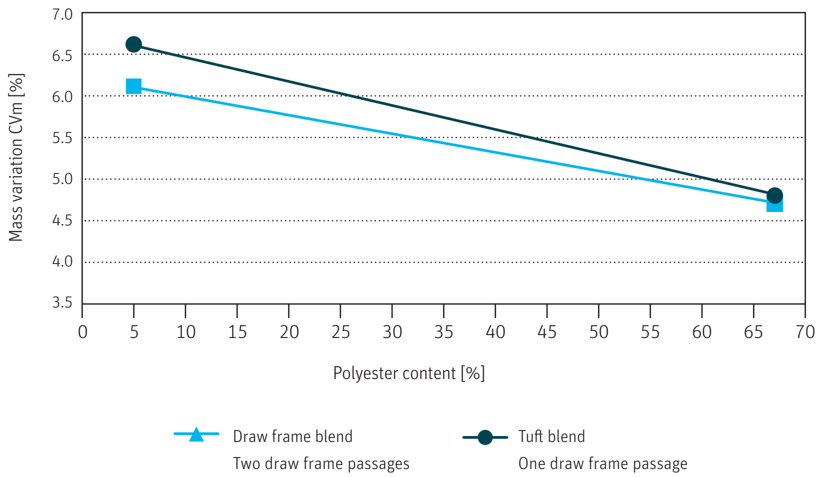
The number of draw frame passages has an influence on the roving evenness with both blending systems. It is better with the draw frame blend. The reason for this could be that the higher number of draw frame passages with the draw frame blend has a positive effect on the parallelization. The difference between the two blending systems is more obvious with little polyester content. This means that a higher number of draw frame passages results in better evenness but is not directly related to the blending precision or blending consistency (Fig. 12).

As expected, an additional draw frame passage improves the CVm value of the mass independent of the blending system. With three respectively two draw frame passages the regularity values of both blending processes lie close to each other. An exception is the blend ratio with 5% polyester for unknown reasons.

This leads to the assumption that the third draw frame passage of the draw frame blend and the second draw frame passage of the the tuft blend improves the evenness of both the tuft and the draw frame blend and mitigates the differences between the two systems. However, the influence of the polyester content on the evenness is greater than the influence of the additional draw frame passage (Fig. 13).

Unevenness roving

Polyester, 1.7 dtex, 38 mm, cotton, 1 1/8", Mic. 4.65, 695 tex

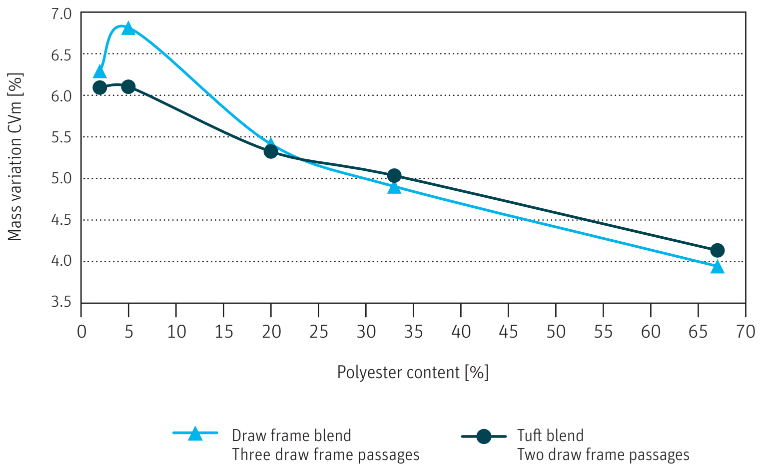


Source: Technology & Process Analytics, TIS 19141

Fig. 12: Higher evenness in the roving with the draw frame blend.

Unevenness roving

Polyester, 1.7 dtex, 38 mm, cotton, 1 1/8", Mic. 4.65, 695 tex



Source: Technology & Process Analytics, TIS 19141

Fig. 13: The polyester content has a greater influence on the evenness than the additional draw frame passage.

5.4. Visual assessment of the tuft blend

The homogeneity and blending are visualized over the following process steps in the spinning process. The fiber mass of cotton and polyester regarding the weight percentage is continuously dosed with the UNIblend. The first prerequisite for good homogeneity is thus fulfilled. The following pictures show that the continuous feeding of the respective raw material components is only the basic prerequisite for good homogeneity. However, the actual blending is influenced by the subsequent process sequences, i.e. by the entire spinning system. It can be deduced from this that the smaller the blending proportion of a particular raw material component, the more important it is to achieve the required homogeneity.

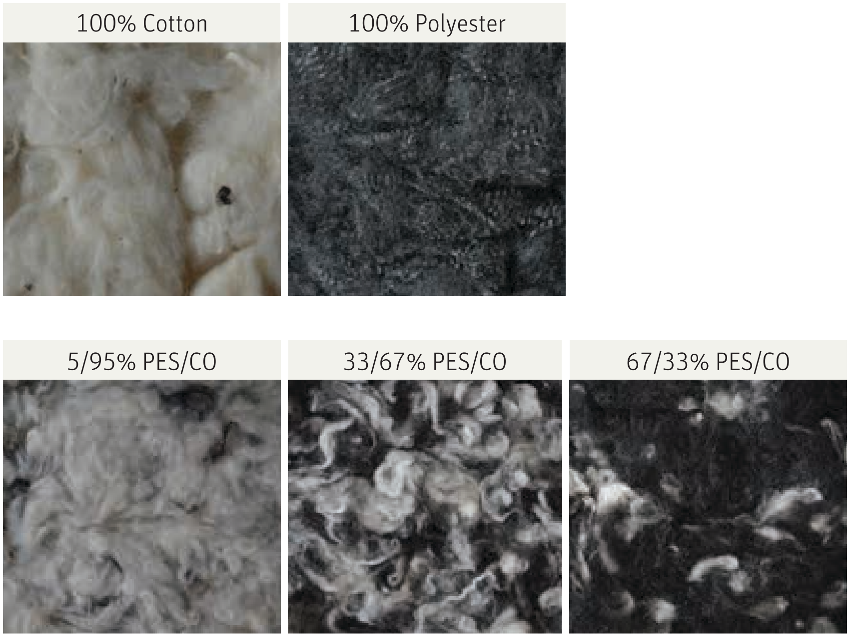


Fig. 14: Homogeneity of the tuft blend after the UNIblend

After the carding process with the constant weight percentage of each raw material component, the blend already looks very homogeneous. Thus, a very good blending already takes place at the card, provided that the raw material components are carded together on the card. In contrast to that, blending only takes place on the subsequent draw frame sections after the card with the draw frame blend.

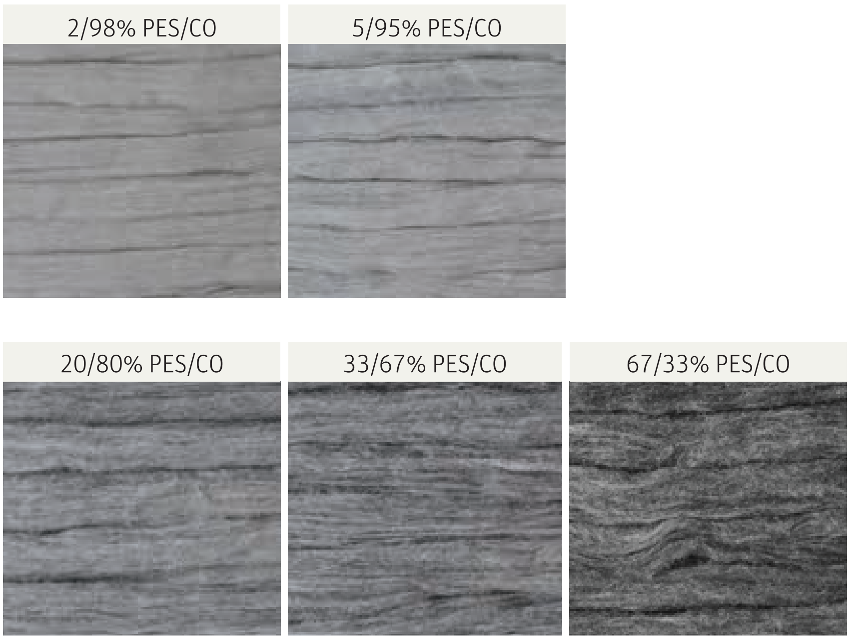


Fig. 15: Homogeneity of the tuft blend after the card

A further increase in homogeneity can be seen after the first draw frame passage.

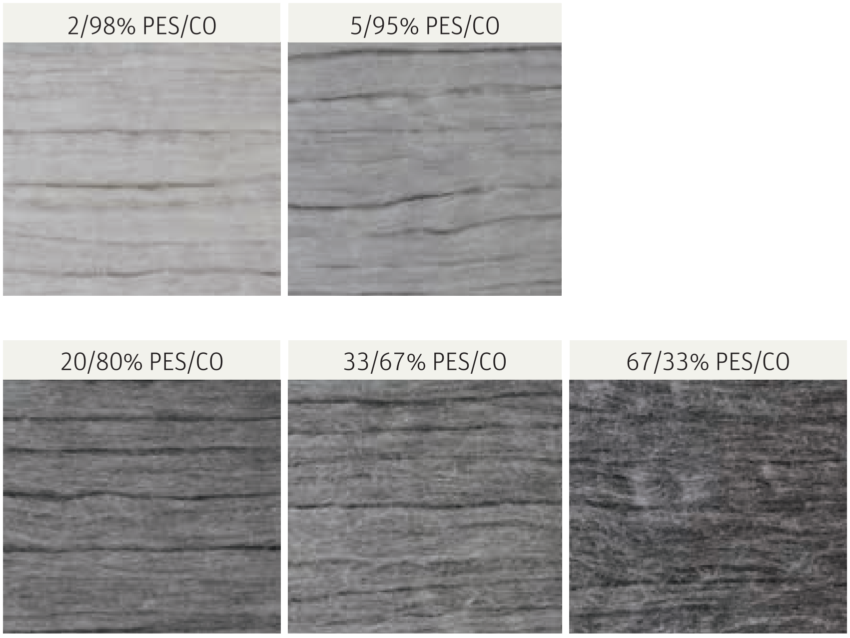


Fig. 16: Homogeneity of the tuft blend after one draw frame passage

After the second draw frame passage, only a minimal increase in homogeneity is visible with the tuft blend.

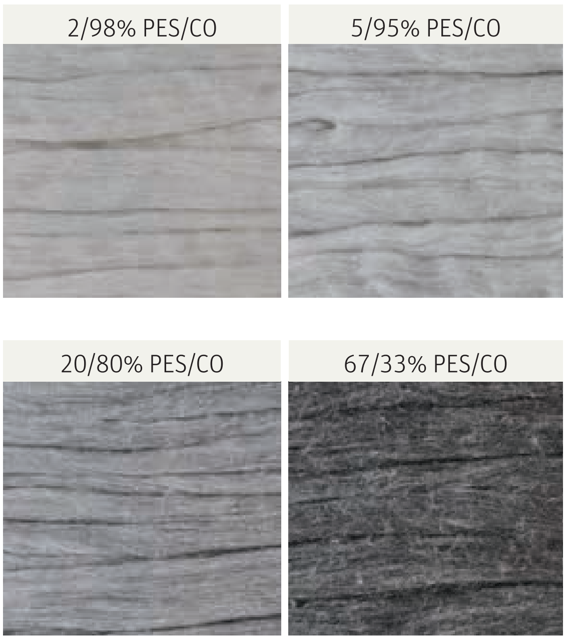


Fig. 17: Homogeneity of the tuft blend after two draw frame passages

Fig. 18: Homogeneity of the tuft blend after the roving frame

5.5. Visual assessment of the draw frame blend

In contrast to the tuft blend, blending on the draw frame starts later in the spinning process. This means that the sliver which reaches the roving frame, or the end-spinning machine is still less homogeneous. The following pictures show how the sliver looks after the blending draw frame, one additional draw frame passage, two additional draw frame passages and the roving frame.

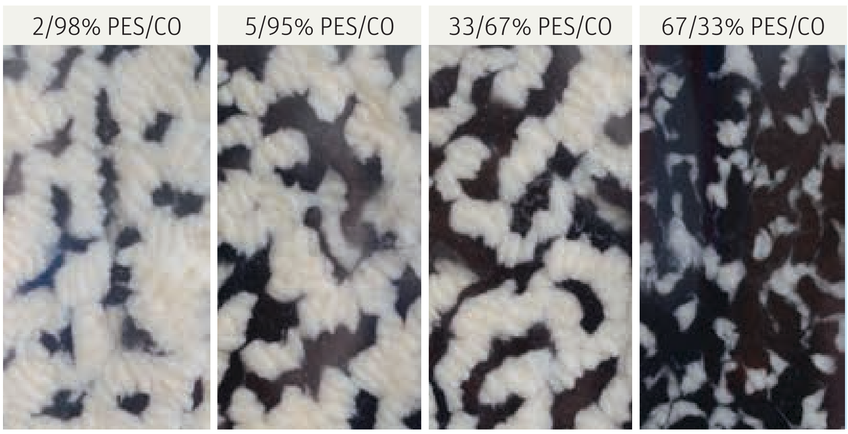


Fig. 19: Homogeneity of the draw frame blend after the blending draw frame

The second draw frame passage improves the result, but it is obvious that even with a blending draw frame and two following passages the same blend homogeneity cannot be achieved as with the tuft blend.

It can be clearly seen that significant blending takes place on the roving frame, but the quality of blending in the draw frame blend is not yet achieved even in the roving. Consequently, the final blending takes place on the end-spinning machine or immediately before the yarn formation process.

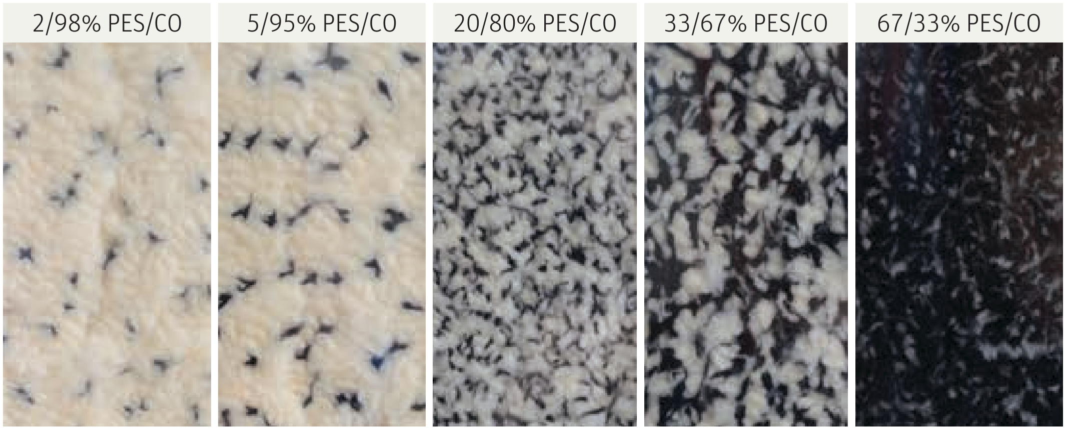


Fig. 20: Homogeneity of the draw frame blend after the second draw frame

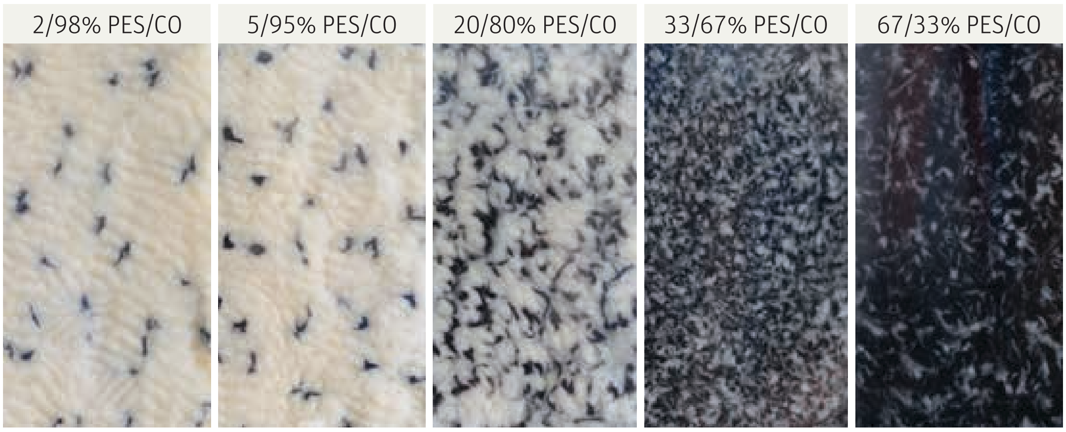


Fig. 21: Homogeneity of the draw frame blend after the third draw frame

Fig. 22: Homogeneity of the draw frame blend after the roving frame

5.6. Comparison of the rovings

The better homogeneity can be seen in the comparison of the roving produced with a tuft blend and a draw frame blend after one draw frame passage and two draw frame passages. A massive difference between the tuft blend and the draw frame blend is visible irrespective of the blending ratios. The greater the color difference of both blending components is, the more obvious this effect becomes.

The number of draw frame passages has a clear influence on the blend when the draw frame blending is used. However, the same blend homogeneity as with the tuft blend cannot be achieved.

Another finding is that for the tuft blend the second draw frame passage has no influence on the homogeneity in the roving. A second draw frame passage might be applied only to achieve a better evenness.

The sliver of the tuft blend is already very homogeneous at an early stage of the spinning process, the sliver of the draw frame blend is still less homogenous when it reaches the roving frame and end-spinning machine.

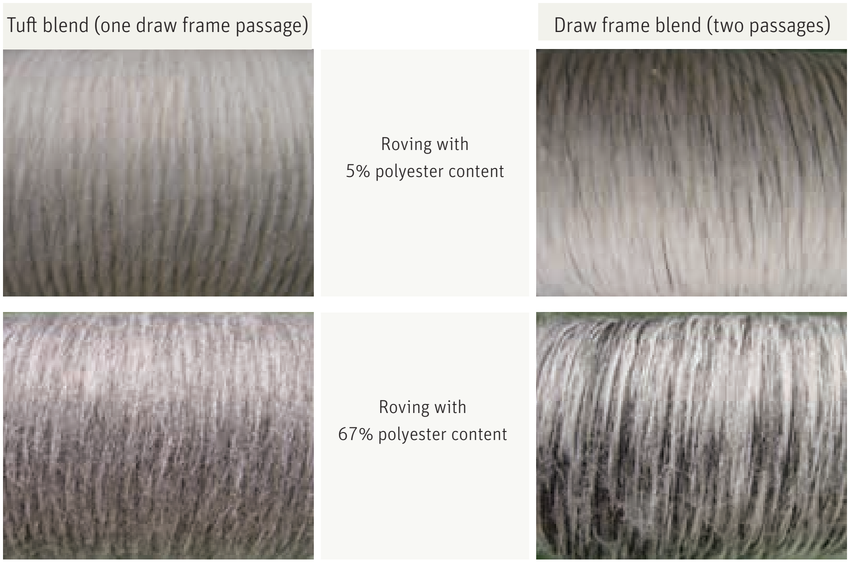


Fig. 23: Comparison of the homogeneity of tuft versus draw frame blend

Fig. 24: Comparison of the homogeneity of tuft versus draw frame blend with an additional draw frame passage

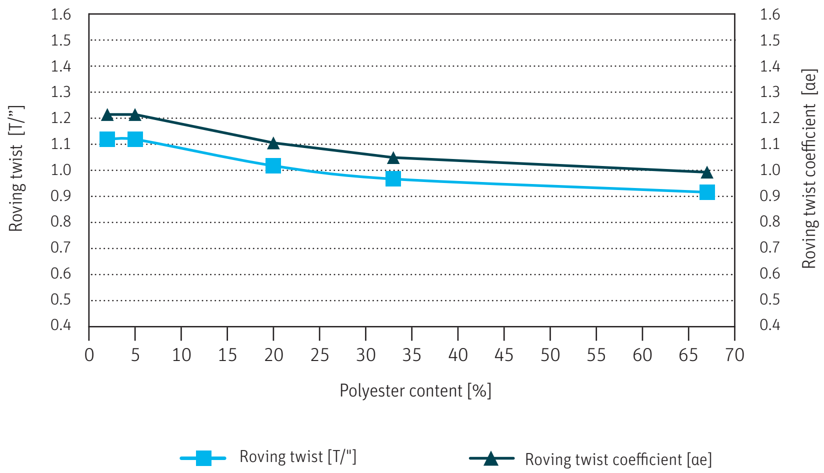
5.7. The influence of the roving twist

Decisive for the optimal quality and the comparability of the ring yarns depending on the blend ratio was the optimal roving twist. With an increasing polyester ratio, the cohesive strength of the roving increases (Fig. 25).

To avoid drafting faults on the ring spinning drafting unit and resulting disadvantages in the yarn quality, the cohesive strength must be accordingly reduced resp. maintained at a constant level.

Roving twist versus blend proportion

Polyester, 1.7 dtex, 38 mm, CO, 1 1/8", Mic. 4.65, 695 tex



Source: Technology & Process Analytics, TIS 19141

Fig. 25: With an increasing polyester ratio, the cohesive strength of the roving increases.

6. Results in the Yarn

6.1. Homogeneity

The better blending with the tuft blend is clearly shown in the yarn cross-sections of the ring yarns. A homogeneous blend has as few fiber groups. The pictures below show that the black spun-dyed polyester fibers are more evenly distributed in the tuft blend whereas fiber groups are clearly visible in the yarn cross-section of the draw frame blend.

With rotor yarn the differences between tuft and draw frame blend are far less visible. This shows that blending is not only dependent on fiber preparation but is also significantly influenced by the end spinning process. And it also clarifies that the rotor spinning technology is better suited for an additional blending of the fibers. This leads to the assumption that the rotor spinning process is more suitable for draw frame blends because here the end-spinning machine is confronted with a less homogeneous sliver and more blending takes place in the rotor spinning machine.

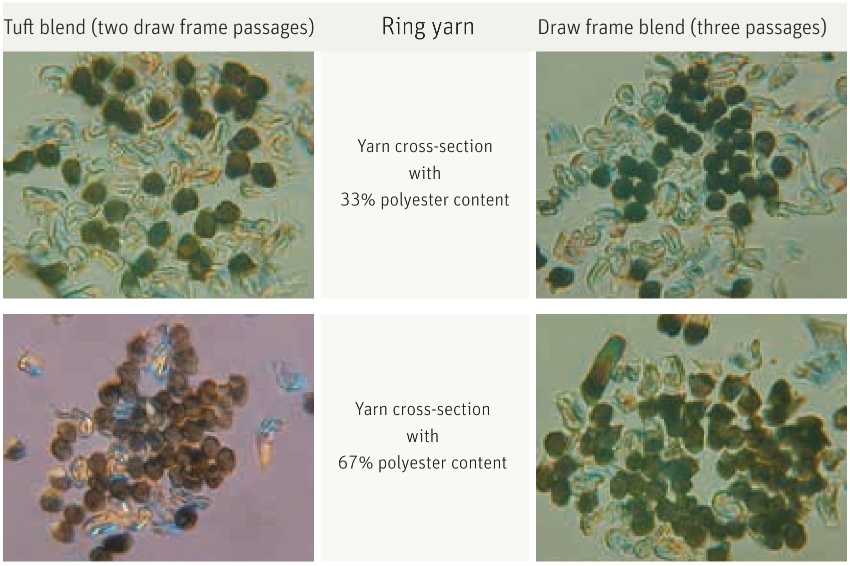


Fig. 26: The yarn cross-sections show more fiber groups in the draw frame blend.

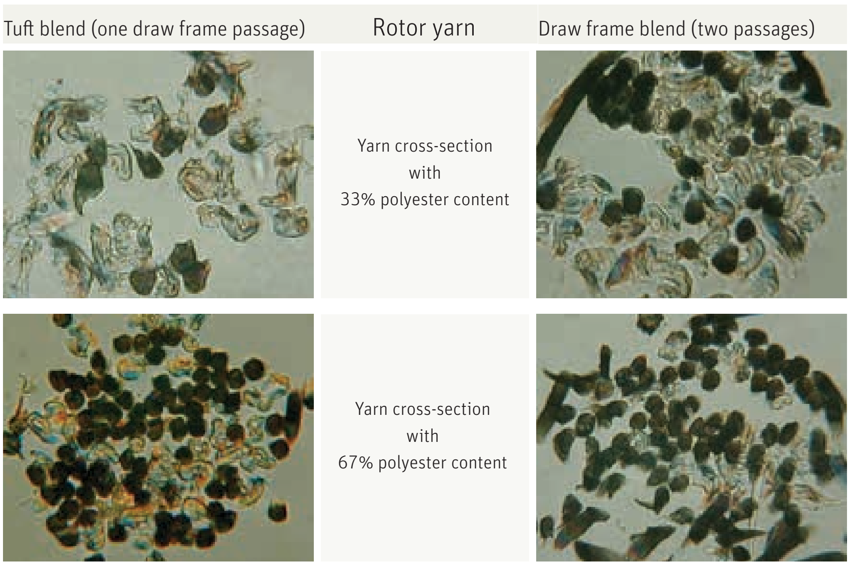


Fig. 27: In the rotor yarn less fibers groups are visible because of the blending taking place in the rotor spinning machine.

6.2. Homogeneity longitudinal

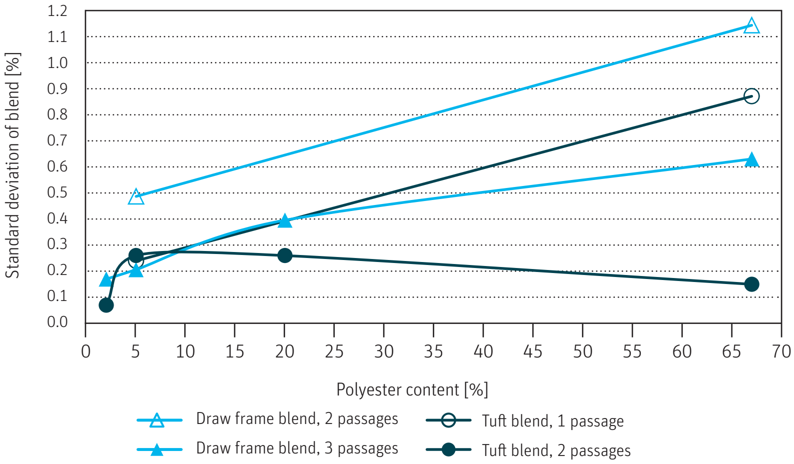
To find out how the homogeneity can differ between the individual blending systems, the "homogeneity longitudinal" or, in other words, the "blending consistency over time" is determined. A very good indicator of blending consistency is the dispersion or standard deviation of the respective blend proportions. This can be found out if the cotton content is chemically dissolved from the yarn and the remaining polyester raw material content is determined gravimetrically. The standard deviation from the mean value can be mathematically calculated on the basis of the weight proportions of the different samples.

In case of the ring yarn, the tuft blend led to a smaller and better standard deviation of the raw material composition. The number of draw frame passages has a positive influence on the blending consistency. With increasing polyester content, it becomes increasingly difficult to obtain the best possible consistency. That means, to achieve a good blend constancy over time is more difficult with a blend of 67/33% (PES/CO) than with 33/67%. The tuft blend with two draw frame passages offers the best results, above all with an increasing polyester content (Fig. 28).

With regard to the rotor yarn the better blending effect of the end-spinning technology compared to the ring yarn is clearly visible. The opening into single fibers by the opening roller and the fiber doubling in the rotor show clear advantages in the blending consistency in comparison to the ring spinning technology. The influence of the blending system, the number of draw frame passages and the polyester content is not as high as in the ring yarn (Fig. 29). However, it can be stated that the UNIblend process with two draw frame passages delivers the best results for both ring and rotor yarn. Only with this process, a standard deviation of the mixing components of 0.15 - 0.2 can be achieved. This value can therefore be recorded as the best possible achievable result. If these very high-quality demands are required in the end application depends on the end product (knitted/woven fabric, yarn count, quality demand) and its dyeing. Light pastel shades in the end product for example usually have a higher demand on homogeneity than very dark colors.

Blending constancy of ring yarn

Polyester 1.7 dtex, 38 mm, Cotton 1 1/8", Mic. 4.65, Ne 30

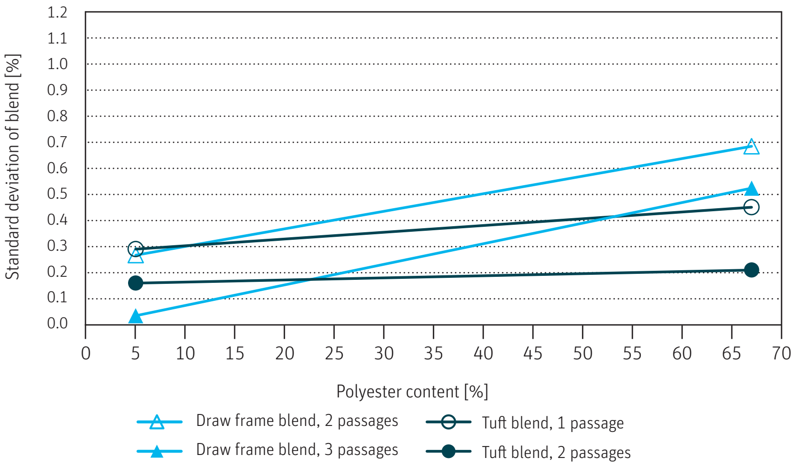


Source: Technology & Process Analytics, TIS 19141

Fig. 28: The tuft blend with two draw frame passages offers the best results in blending constancy.

Blending constancy of rotor yarn

Polyester 1.7 dtex, 38 mm, Cotton 1 1/8", Mic. 4.65, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 29: The rotor technology has a better blending effect.

6.3. Fiber substance utilization

The “fiber substance utilization” is the relative comparison how successful the impact of the fiber strength in the yarn bundle is. That means the fiber strength yield.

The fiber-fiber friction and therefore the fiber substance yield is considerably affected by the raw material components and the yarn structure. The cross-blending and thereby the blending system does, however, influence the fiber substance yield.

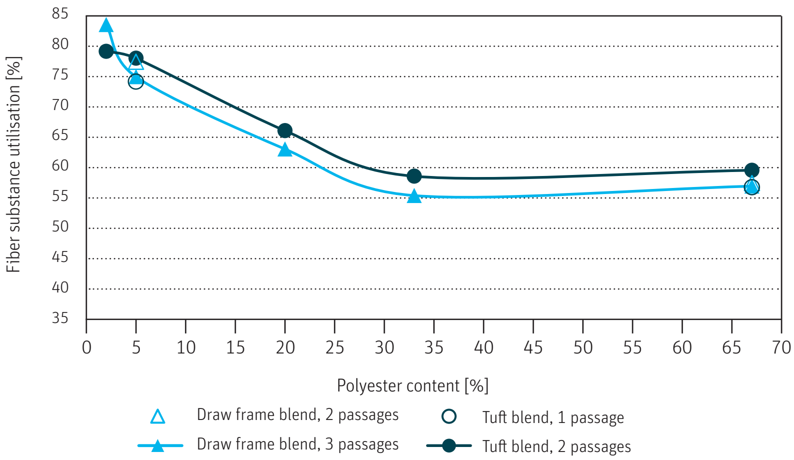
By means of the tuft blend, an approx. 4% better fiber substance yield of the fibers can be attained on the ring yarn (Fig. 30). The improved blending has a positive effect on the fiber bonding and consequently on the “fiber-fiber” friction. With increasing polyester content, the fiber substance yield worsens. An increasing proportion of fibers with higher strength of up to 35% leads to a decrease in the “fiber substance yield”. This means that the yarn tenacity in absolute terms does not improve to the same extent as the proportion of fibers with higher fiber strength increases. In relative terms, therefore, the fiber substance yield decreases. The reason is that the coefficient of friction between the fibers decreases with increasing polyester content up to a certain level due to the fiber stiffness and the round fiber cross-section, and the polyester fibers do not bind as easily as cotton.

Rotor yarn has a massively worse fiber substance utilization than a ring yarn, due to the yarn structure. The substance yield fluctuates from 40 – 55% according to polyester content (Fig. 31). Because of the blending effect created by the rotor technology, the fiber substance yield is not improved with the tuft blend. The draw frame blend with two draw frame passages achieves the same fiber substance yield as the tuft blend.

That means that the fiber substance utilization with rotor yarn is primarily influenced by polyester content and rotor yarn structure, but not by the blending system.

Fiber substance utilization ring yarn

Polyester, 1.7 dtex, 38 mm, cotton, 1 1/8", Mic. 4.65, Ne 30

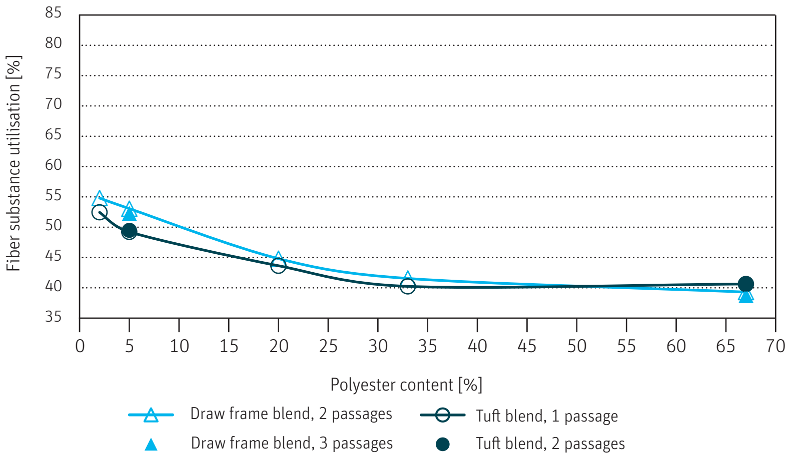


Source: Technology & Process Analytics, TIS 19141

Fig. 30: The fiber substance utilization is better with the tuft blend.

Fiber substance utilization rotor yarn

Polyester, 1.7 dtex, 38 mm, cotton, 1 1/8", Mic. 4.65, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 31 Rotor yarn has a worse fiber substance utilization than ring yarn.

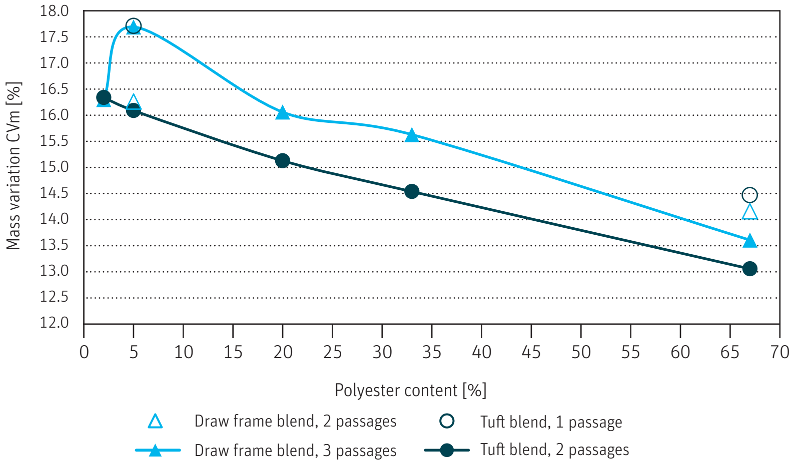
6.4. Yarn evenness

In a next step it was examined how the yarn evenness is influenced by the blending system: The tuft blend reaches a 0.5 – 1% better evenness than the draw frame blend in the ring yarn (Fig. 32). This result confirms that values from the sliver and roving (such as fiber length utilization, cohesive length and evenness in sliver and roving) don't necessarily apply for the yarn. This is because in the end, the yarn regularity is also an interaction between the fiber preparation and the end-spinning system such as ring or rotor. Blending is influenced by the entire system not only the stages in fiber preparation.

For example, despite better evenness in the draw frame sliver, the sliver adhesion length can decrease and thus worsen the evenness in the downstream process stages. Or a high fiber parallelism can cause fiber spreading in the downstream process stages and thus result in more fiber neps at the ring traveler system of the ring spinning machine.

Unevenness of ring yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30

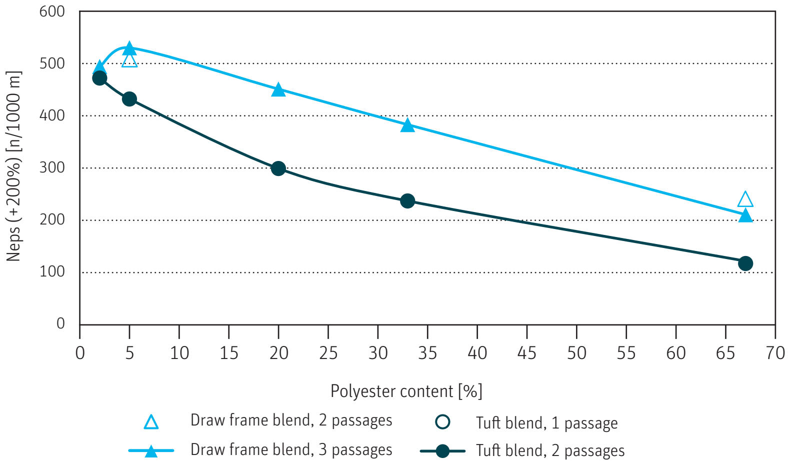


Source: Technology & Process Analytics, TIS 19141

Fig. 32: The tuft blend reaches a 0.5–1% better evenness than the draw frame blend in the ring yarn.

Neps of ring yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30



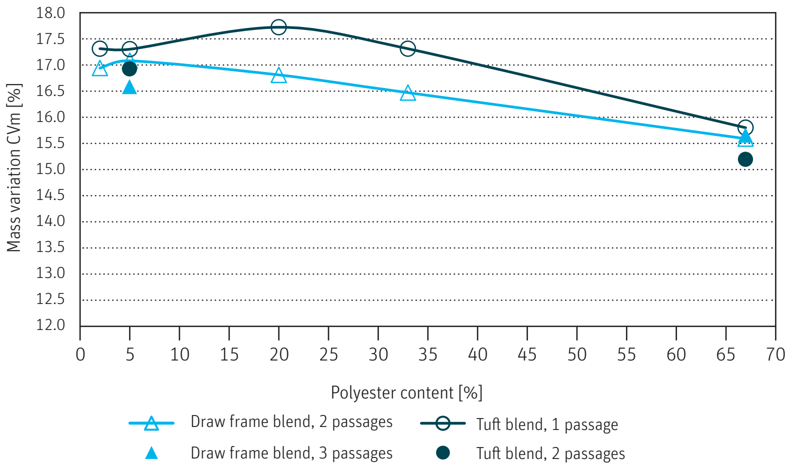
Source: Technology & Process Analytics, TIS 19141

Fig. 33: The number of neps is lower with the tuft blend.

As observed before in rotor yarns the end-spinning process plays a more important role. When only two draw frame passages are used in the draw frame blend and one draw frame passage in the tuft blend, the draw frame blend shows a better evenness compared to the tuft blend (Fig. 34). However, with a third/second draw frame passage, the differences in evenness no longer occur. This confirms that the yarn evenness is an interplay between fiber preparation and end-spinning process. If the quality requirements are very high, three draw frame passages should be used on the draw frame blend and two on the tuft blend to secure the best possible regularity also in the rotor yarn.

Unevenness of rotor yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30

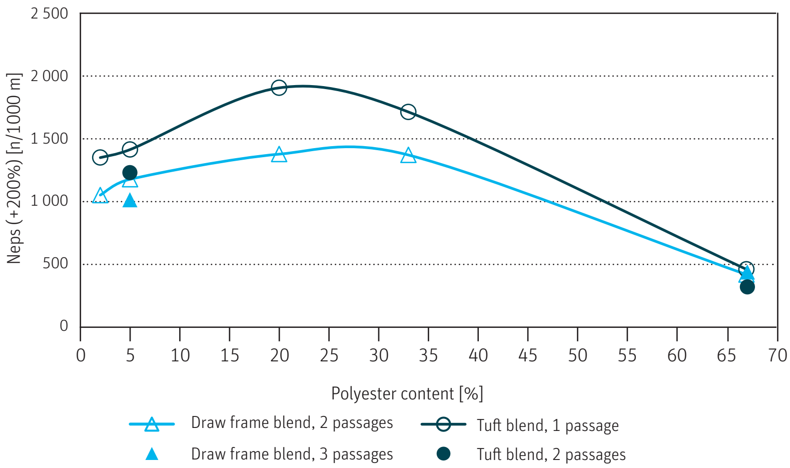


Source: Technology & Process Analytics, TIS 19141

Fig. 34: The rotor technology plays an important role for the yarn evenness.

Neps at rotor yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 35: In rotor yarn, the number of neps is higher with the tuft blend.

6.5. Tenacity and elongation

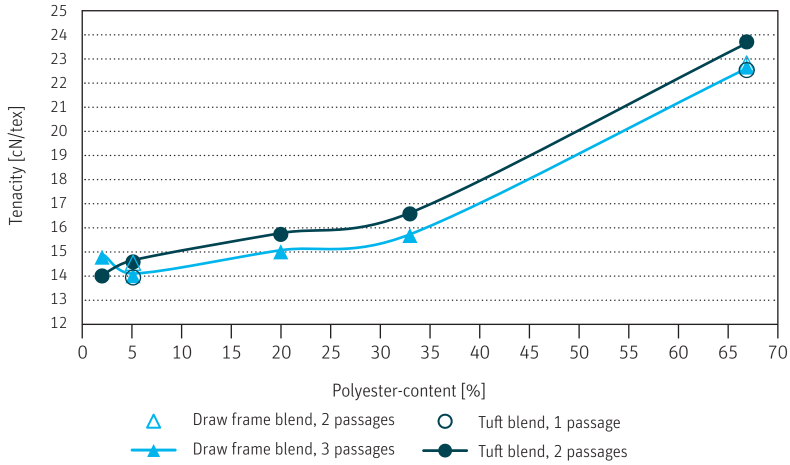
Concerning the ring yarn, the tuft blend has a 1cN/tex higher tenacity than the draw frame blend when an additional draw frame passage is used (Fig. 36). The usage of two draw frame passages in the tuft blend is slightly better as far as tenacity is concerned than only one draw frame passage.

The yarn tenacity is thereby positively influenced, not only by the blending system UNIblend but also by a higher number of draw frame passages. The yarn tenacity rises with increasing polyester content due to the higher fiber strength of this raw material compared to cotton.

Neither the blending system nor the number of draw frame passages have shown any influence on the yarn elongation with ring and rotor yarn. The elongation is only influenced by the polyester content and by the end spinning process, whether ring or rotor (Fig. 36 and 39).

Tenacity of ring yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30

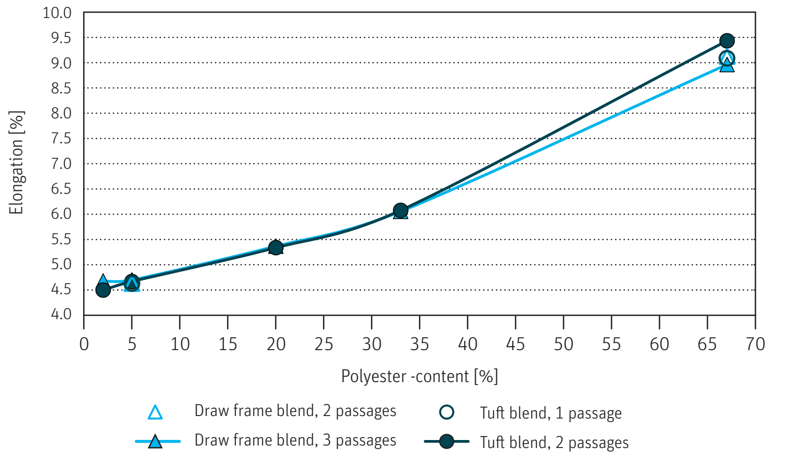


Source: Technology & Process Analytics, TIS 19141

Fig. 36: The tuft blend has a 1cN/tex higher tenacity than the draw frame blend.

Elongation of ring yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic. 4.65, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 37: Elongation is only influenced by the polyester content and by the end spinning process.

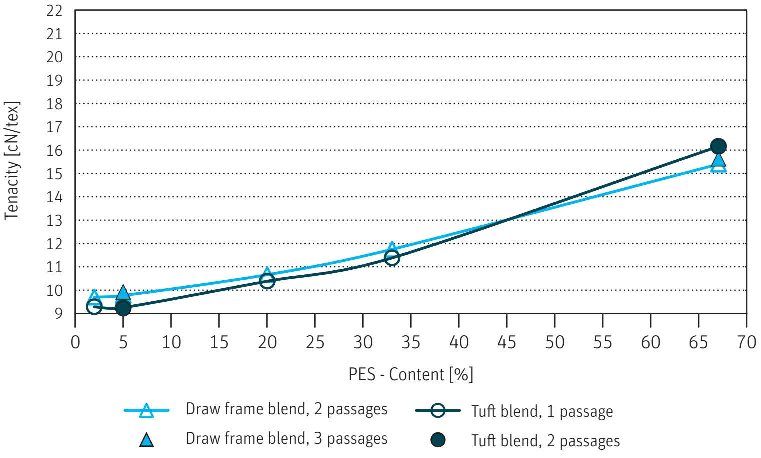
With the end spinning system of rotor yarn, the influences of the fiber preparation are lower than with ring yarn because of the yarn structure and the blending effect.

The yarn tenacity does not allow a clear statement to be made regarding the influence of the blending system. Also the number of draw frame passages does not appear to have an influence on rotor yarn (Fig. 38).

With a polyester ratio of 5 to 33%, the rotor yarn has an elongation approximately 0.5 to 1% higher than the ring yarn. With a higher polyester content, the influence of polyester is greater than the influence of the yarn structure. Therefore, with a polyester content of more than 33%, no differences exist in the yarn elongation between a ring and a rotor yarn structure (Fig. 36 and Fig. 39).

Tenacity of rotor yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30

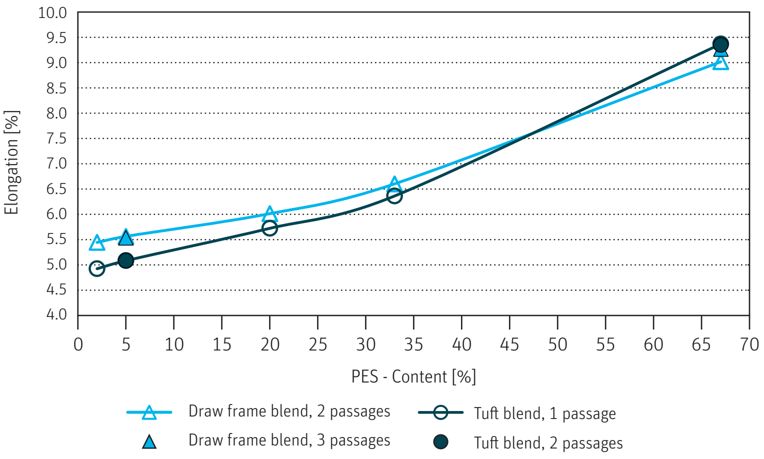


Source: Technology & Process Analytics, TIS 19141

Fig. 38: The blending system and the number of draw frame passages don't seem to have an influence on the tenacity.

Elongation of rotor yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 39: Yarn elongation is mainly influenced by the polyester content.

6.6. Hairiness

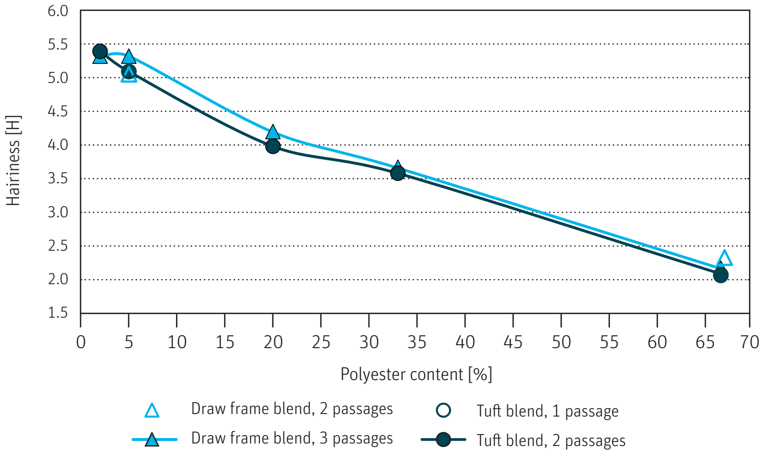
The tuft blend showed a minimally lower hairiness compared to the draw frame blend with ring yarn (Fig. 40). The number of draw frame passages with the respective blending systems, however, had no effect. The effect can be explained with a slightly worse homogeneity of the polyester-cotton blend, the polyester fibers tend to accumulate more in the center of the yarn body. In the outer area, there are more cotton fibers which because of their higher short-fiber proportion then also lead to less integration in the yarn body. That means, the effect must then diminish also with an increasing polyester ratio between the two blending systems. This does also seem to be the case. With the small polyester blend addition, the influence of the higher short-fiber ratio due to the cotton is higher than the influence of the blending system. In this respect, the results are plausible.

Due to the decreasing short-fiber ratio with increasing polyester ratio, the hairiness is reduced clearly and linearly.

An influence of the blending system on the hairiness is already no longer detectable with rotor yarn (Fig. 41). Equally, the number of draw frame passages on both blending systems has no influence on hairiness. With ring and rotor yarn, it can be clearly recognized that hairiness becomes reduced with increasing polyester content. A rotor yarn, due to its yarn structure, is far less hairy than a ring yarn.

Hairiness of ring yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30

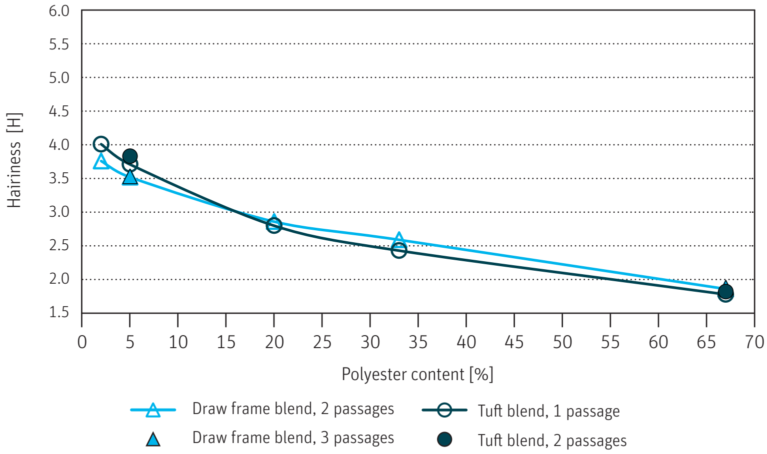


Source: Technology & Process Analytics, TIS 19141

Fig. 40: With ring yarn, the influence of the blending system on hairiness is small, hairiness reduces with an increasing polyester content.

Hairiness of rotor yarn

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 41: With rotor yarn, an influence of the blending system on hairiness is not detectable.

7. Results in the Knitting

Knitted fabrics were created to find out whether the results from the yarn are also reflected in the downstream processes.

7.1. Shrinkage

The fabric weight is independent of the blend ratio. The fabric weights of the finished knits are approximately 15% higher than those of the greige knitted fabrics because of shrinkage of the knitted goods (Fig. 42). The rise with an increasing polyester ratio can only be explained by the variation of the yarn count or a greater shrinkage.

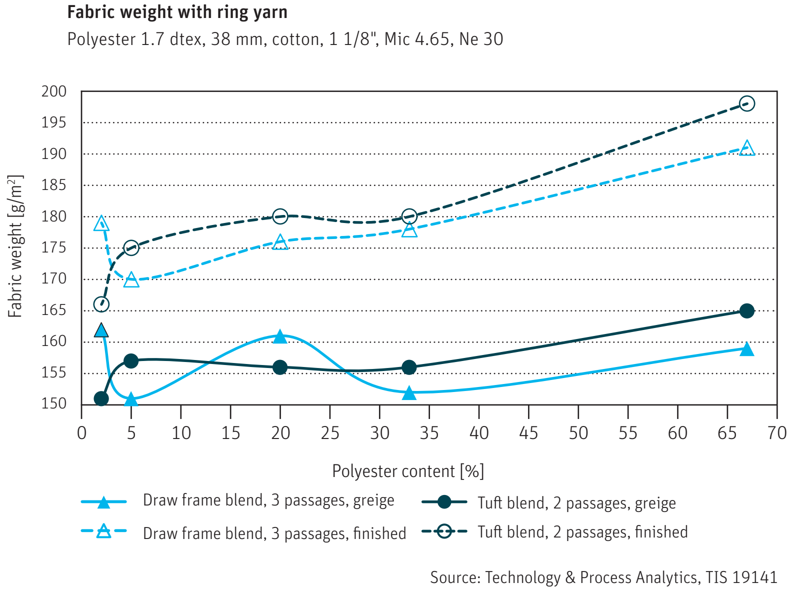


Fig. 42: The fabric weights of the finished knits are approximately 15% higher than those of the greige knitted fabrics.

On the rotor yarn knitted fabric, the weight increase is confirmed by the shrinkage with approximately 12%. However, no increase is shown here in the fabric weight with increasing polyester content (Fig. 43).

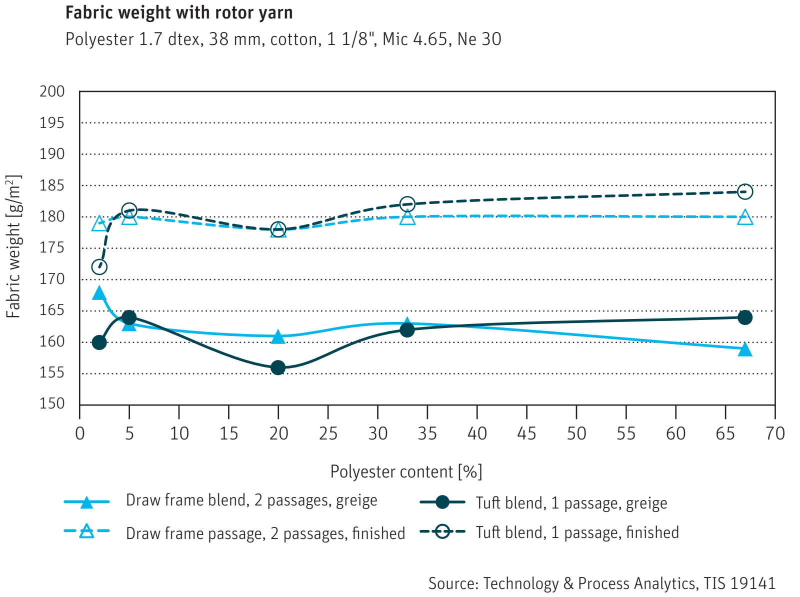


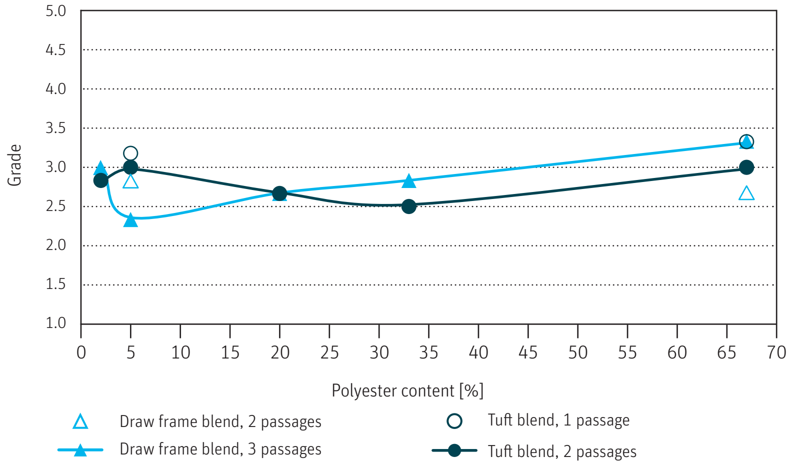
Fig. 43: In contrast to ring yarn, there is no increase in fabric weight with increasing polyester content with rotor yarn.

7.2. Pilling

Between the two blending systems, no clear differences are visible in the pilling after 7 000 cycles. Only with increasing polyester content the pilling values are slightly better, due to the reduced hairiness and the higher "bending-rigidity" with the applied polyester fiber, compared to cotton (Fig. 44).

Knitted fabric ring yarn, undyed after 7 000 cycles

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic 4.65, Ne 30



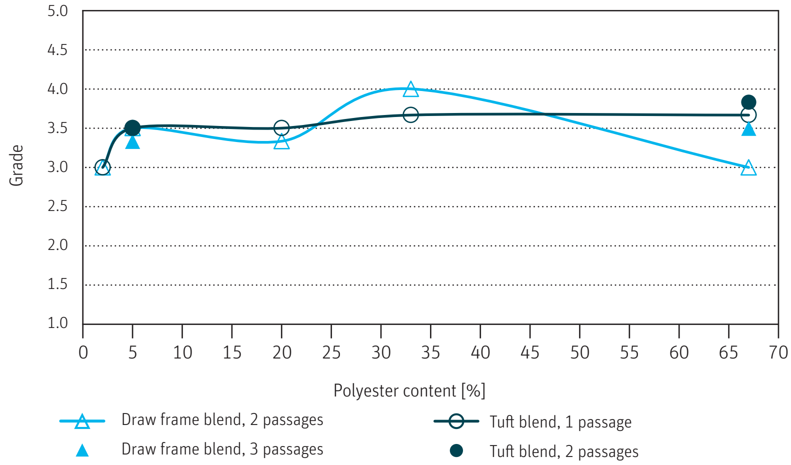
Source: Technology & Process Analytics, TIS 19141

Fig. 44: There are no clear differences visible in the pilling after 7 000 cycles between the two blending systems.

The positive influence on the pilling behavior due to the rotor yarn structure is greater than the influence of the mixing process or the polyester-cotton ratio. The rotor yarn is approximately one pilling grade better than the ring yarn (Fig. 45).

Knitted fabric rotor yarn, undyed after 7 000 cycles

Polyester 1.7 dtex, 38 mm, cotton 1 1/8", Mic. 4.65, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 45: The rotor yarn is approximately one pilling grade better than the ring yarn, see Fig. 44.

7.3. Optical structure

The tuft blend gave a more even appearance of the fabric made of ring yarn than the draw frame blend (Fig. 46). The evenness is characterized by fewer yarn defects and a better homogeneity of the fabric surface.

The fabrics made of rotor yarn are different because of the special rotor yarn structure. The coverage of rotor yarns is better than the one of ring yarns due to a larger yarn diameter despite having the same yarn count. However, due to the yarn structure the yarn unevenness in the short-wave yarn length range is higher than in a ring yarn. Due to the better fiber blending effect on the rotor spinning machine, the influence of the blending system in fiber preparation is much smaller. Nevertheless, even with the rotor yarn structure a better homogeneity can be seen in favor of the tuft blend (Fig. 47).

For this reason, the use of only two draw frame passages for the draw frame blend and one for the tuft blend are usually sufficient in practice. Only in the case of extremely high-quality requirements three (for draw frame blend) respectively two draw frame passages (for tuft blend) are recommended in rotor spinning.

Knitting structure ring

2/98% polyester/cotton – Tuft blend
2 draw frame passages

2/98% polyester/cotton – Draw frame blend
3 draw frame passages

Fig. 46: With ring yarn, the tuft blend resulted in a more even fabric appearance.

Knitting structure rotor

2/98% polyester/cotton – Tuft blend
1 draw frame passage

2/98% polyester/cotton – Draw frame blend
2 draw frame passages

Fig. 47: Due to the better blending effect on the rotor spinning machine, the influence of the blending system is smaller.

8. Further Influences: White Spots and Barréness

It is important to note that the fabric quality of cotton-polyester blends is not only influenced by the homogeneity of the raw material blend over time.

There are other important quality parameters as well. These are:

- "White spots" which are primarily important in mélange applications where only one raw material component in the fabric is dyed later.
- "Barréness" due to fiber fineness variations of the cotton.

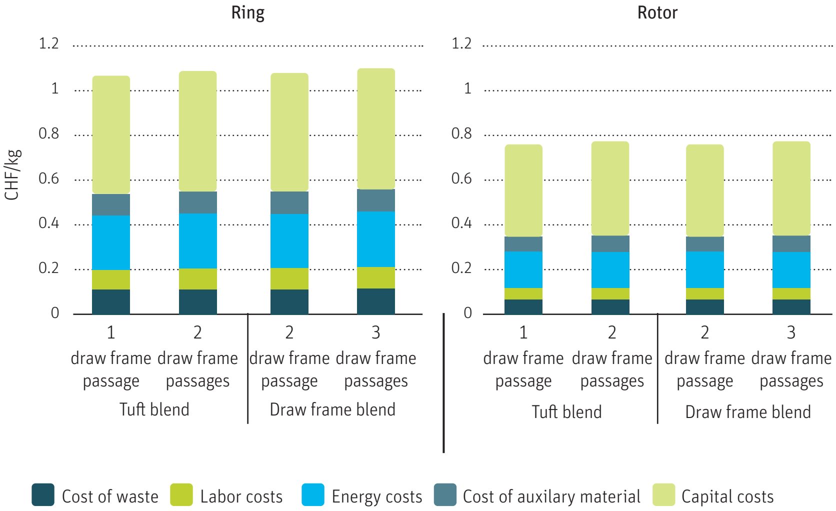
The avoidance of "white spots", i.e. disturbing neps or thick spots in the fabric, is of great importance in the requirements of mélange applications due to optimum polyester opening and avoidance of polyester fiber curling over the individual process stages. These fiber curls, which can occur over the different process stages, then show up in rare yarn defect events. Due to its scope, this subject will be dealt with in a further study and as a supplement to this publication.

The avoidance of barréness in the fabric after dyeing must be achieved with a targeted bale management and with focus on the constancy of the fiber fineness. The definition and selection of the various cotton raw material origins according to the important criterion of fiber fineness and degree of maturity is important here. In practice, calculation methods already exist for optimally combining the cotton origins in this respect.

9. Profitability

In addition to the quality aspects, an important criterion for deciding on a blending process is the profitability. The calculation shows that the yarn manufacturing costs for modern high-productivity process stages are similar for tuft blending using the UNIblend A 81 as for blending that is carried out on the draw frames (Fig. 48). In the case of tuft blending, the reasons are a simpler material flow and thus a more efficient machine utilization. Furthermore, the respective process stages in fiber preparation have a smaller impact on the capital costs of yarn production than the end-spinning machines. Thus, qualitative reasons and the end-spinning process should be the decisive factors for the selection of the respective blending system. The spinning plans on which the calculation is based on are attached in the appendix.

Cost comparison for tuft and draw frame blending in Turkey
50/50% polyester, 1.7 dtex, 38 mm, cotton, 1 1/8", Mic. 4.5, Ne 30



Source: Technology & Process Analytics, TIS 19141

Fig. 48: The yarn manufacturing costs are similar for tuft blending as for blending that is carried out on the draw frames.

10. Summary

The investigation has analyzed the influence of the tuft blending and the draw frame blending on homogeneity. It could be shown that the blending is influenced by the entire system and not only by a single process stage. The end-spinning machine but also the card take over an important part of the blending process and influence the homogeneity. Therefore, it does not necessarily make sense to add further draw frame passages if the result in the sliver is unsatisfactory.

Homogeneity is significantly influenced by a constant dosing of the respective raw material components. Optimum dosing is best determined by keeping the fiber mass to be fed constant over time.

The composition of the blend also plays a role as the different raw materials have different characteristics. Polyester for example has a higher tenacity and thus, the amount of polyester in the blend influences the quality criteria of the sliver, roving, yarn and fabric. As the yarn manufacturing costs are the same for both blending systems, the decision can be made solely based on quality requirements and the end-spinning process.

Recommendations for ring yarn:

- For ring yarn the tuft blending is more suitable in general. The yarn cross sections have shown that the continuous fiber feeding executed by the UNIblend ensures the best homogeneity. Less fibers blending takes place in the ring spinning machine compared to the rotor spinning machine.
- The polyester content in the blend has a higher influence in the ring yarn as in the rotor yarn. The tuft blending followed by two draw frame passages, a reaches the best blending consistencyalso with a high polyester content.
- The evenness and tenacity in the ring yarn show the best values with the tuft blend followed by two draw frame passages.
- The blending system has no or only very little influence on yarn elongation and hairiness. There the end-spinning system and the polyester content play a more important role.
- If a draw frame blend is applied for ring yarn, there should be three draw frame passages.

Recommendations for rotor yarn:

- Due to the better fiber blending effect on the rotor spinning machine, the influence of the blending system in fiber preparation is much lower for rotor yarn.
- Draw frame blending starts late in the spinning process, thus the rotor spinning machine takes over a bigger part of the blending work. As a result, the draw frame blend is more suitable for rotor yarn.
- For rotor yarn, usually two draw frame passages with the draw frame blend are sufficient to reach reasonable blend constancy.
- However, in the case of very high-quality requirements, the tuft blend followed by two draw frame passages is recommended as this process delivers the best results.
- The polyester content does not influence the homogeneity and evenness in the rotor yarn as much as in the ring because of the rotor yarn structure.

11. Process Recommendations

	Ring Application	Rotor Application
	Tuft Blend	
Tuft blend (two draw frame passages)	**High requirement to:** • Blend constancy over time • Fiber substance utilization • Yarn evenness Ne 30 or finer Polyester content 5 – 95%	**Very high requirement to:** • Blend constancy over time Ne 20 or finer Polyester content 5 – 95%
Tuft blend (one draw frame passage)	**Normal to medium requirement to:** • Blend constancy over time • Fiber substance utilization • Yarn evenness Ne 30 or finer Polyester content 5 – 95%	**High requirement to:** • Blend constancy over time Ne 20 or finer Polyester content 5 – 95%

	Ring Application	Rotor Application
	Draw frame blend	
Draw frame blend (three draw frame passages)	**Normal to medium requirement to:** • Blend constancy over time • Yarn evenness Ne 30 or finer Polyester content 50 – 70%	**High requirement to:** • Blend constancy over time • Yarn evenness Ne 20 or finer Polyester content 20 – 70%
Draw frame blend (two draw frame passages)	**Medium requirement to:** • Blend constancy over time • Yarn evenness Ne 30 or coarse Polyester content 50 – 70%	**Normal to medium requirement to:** • Blend constancy over time • Yarn evenness Ne 20 or finer Polyester content 20 – 70%

12. Appendix

The profitability was calculated using the following spinning plans

Spinning Plan for Ring Spinning Process

Tuft blend (two draw frame passage)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21				A 81 – B 72 – A 21 – B 72 – A 21			
Blowroom polyester	B 34S – A 79 – A 21							
Card	C 75			114.3	6 561	80 kg/h 203 m/min		
Draw frame	SB-D 50	6 561	6	7.3	5 368	800 m/min		
Draw frame	RSB-D 50	5 368	6	6	5 368	800 m/min		
Roving frame	F 40	5 368	1	7.3	738		29	34
Ring spinning	G 38	738		36.9	20	18 600 rpm	113	800

Tuft blend (one draw frame passage)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21				A 81– B 72 – A 21 B 72 – A 21			
Blowroom polyester	B 34S – A 79 – A 21							
Card	C 75			114.3	6 561	80 kg/h 203 m/min		
Draw frame	RSB-D 50	6 561	6	7.3	5 368	800 m/min		
Roving frame	F 40	5 368	1	7.3	738		29	34
Ring spinning	G 38	738		36.9	20	18 600 rpm	113	800

Draw frame blending (three draw frame passages)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21							
Blowroom polyester	B 34S – A 79 – A 21							
Card cotton	C 75			121.9	6 561	85 kg/h 216 m/min		
Card polyester	C 75			106.7	6 561	100 kg/h 254 m/min		
Draw frame blending	SB-D 50	6 561	6	7.3	5 368	800 m/min		
Draw frame	SB-D 50	5 368	6	6	5 368	800 m/min		
Draw frame	RSB-D 50	5 368	6	6	5 368	800 m/min		
Roving frame	F 40	5 368	1	7.3	738		29	34
Ring spinning	G 38	738		36.9	20	18 600 rpm	113	800

Draw frame blending (two draw frame passages)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21							
Blowroom polyester	B 34S – A 79 – A 21							
Card cotton	C 75			121.9	6 561	85 kg/h 216 m/min		
Card polyester	C 75			106.7	6 561	100 kg/h 254 m/min		
Draw frame blending	SB-D 50	6 561	6	7.3	5 368	800 m/min		
Draw frame	RSB-D 50	5 368	6	6	5 368	800 m/min		
Roving frame	F 40	5 368	1	7.3	738		29	34
Ring spinning	G 38	738		36.9	20	18 600 rpm	113	800

Spinning Plan for Rotor Spinning Process

Tuft blend (two draw frame passages)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21				A81 – B 72 – A21 – B 72 – A21			
Blowroom polyester	B 34S – A 79 – A 21							
Card	C 75			114.3	6 561	90 kg/h 229 m/min		
Draw frame	SB-D 50	6 561	6	8	4 921	800 m/min		
Draw frame	RSB-D 50	4 921	6	8	4 921	800 m/min		
Rotor spinning	R 70	4 921		246.1	20	125 000 rpm	113	800

Tuft blend (one draw frame passages)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21				A 81 – B 72 – A21 – B 72 – A21			
Blowroom polyester	B 34S – A 79 – A21							
Card	C 75			114.3	6 561	90 kg/h 229 m/min		
Draw frame	SB-D 50	6 561	6	8	4 921	800 m/min		
Rotor spinning	R 70	4 921		246.1	20	125 000 rpm	113	800

Draw frame blending (three draw frame passages)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21							
Blowroom polyester	B 34S – A 79 – A 21							
Card cotton	C 75			121.9	6 561	115 kg/h 292 m/min		
Card polyester	C 75			106.7	6 561	100 kg/h 254 m/min		
Draw frame blending	SB-D 50	6 561	6	8	4 921	800 m/min		
Draw frame	SB-D 50	4 921	6	6	4 921	800 m/min		
Draw frame	RSB-D 50	4 921	6	6	4 921	800 m/min		
Rotor spinning	R 70	4 921		246.1	20	125 000 rpm	113	800

Draw frame blending (two draw frame passages)

Machine	Type	Feed	Doubl.	Draft	Output	Delivery	Twist	
		[tex]	[fold]	[fold]	[tex]		[αm]	[T/m]
Blowroom cotton	A 12 – B 25 – A 22 – B 12 – B 76 – A 79 – A 21							
Blowroom polyester	B 34S – A 79 – A 21							
Card cotton	C 75			121.9	6 561	85 kg/h 216 m/min		
Card polyester	C 75			106.7	6 561	100 kg/h 254 m/min		
Draw frame blending	SB-D 50	6 561	6	8	4 921	800 m/min		
Draw frame	RSB-D 50	4 921	6	6	4 921	800 m/min		
Rotor spinning	R 70	4 921		246.1	20	125 000 rpm	113	800

13. Notes

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