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Processing of Polyester Fibers

Processing characteristics of Alya polyester fibers from M&G on Rieter spinning machines

PREFACE

Ascertaining the processing properties of new fibers in modern high-performance spinning processes is an ongoing process with a view to optimizing the design of the fibers, the spinning machines, the overall spinning schedule and downstream processing of the yarn. For Rieter as a manufacturer of textile machinery and for the fiber producer M&G (Gruppo Mossi & Ghisolfi) the main goal is to develop know-how and provide the best support to customers, the spinning mills. This goal is achieved in close cooperation between the spinning machinery manufacturer and fiber producer by running tests with new man-made fibers, and blends thereof, on Rieter high performance spinning machines. The customer benefits from the possibilities to develop new products.

This paper presents the results of such a cooperation between Rieter and M&G. Starting point is the evaluation of processing characteristics with new fibers on high-performance spinning machines in the spinning process up to determining the quality value of the raw material, intermediate product and yarn.

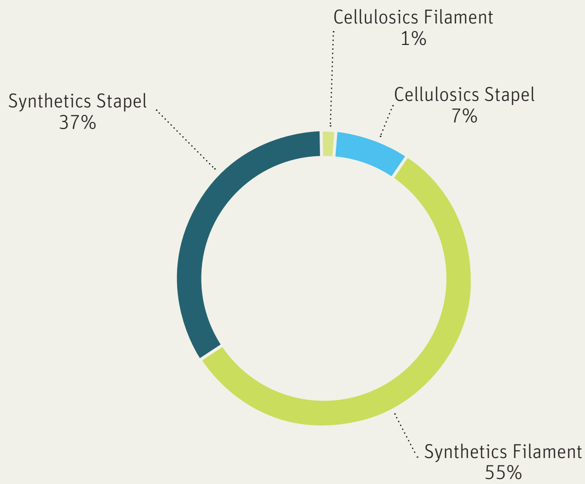

Fig. 1 – Man-made fiber production worldwide

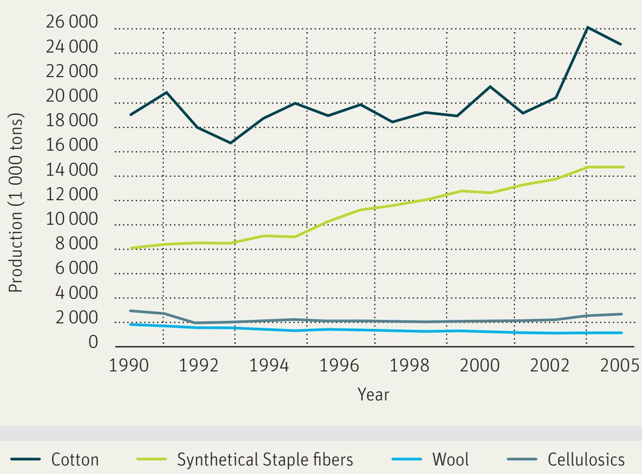

Fig. 2 – Staple fiber production worldwide

FIBER PRODUCTION WORLDWIDE

The synthetic staple fiber production plays an important role with about 37% of the worldwide production (Fig. 1). In 2004, cotton production exceeded for the first time 26 millon tons. Over the years cotton production has remained more or less at a constant level of about 20 million tons per year. The demand for synthetics, however, has been increasing in the last ten years. Almost 15 million tons of synthetics were produced in 2005.

Synthetics can be divided into different material groups: Polyester, Acrylic, Polyamide and Olefins. The biggest increase is clearly noted for polyester. For polyester alone production increased from roughly 5.5 million tons in 1995 to 10 million tons in 2005.

Polyester staple fibers and its blends are found in various applications:

- Clothing
- Bedding
- Sportswear
- Home furnishings

ALYA POLYESTER FIBER WITH VARIABLE STAPLE LENGTH

The new Alya W 110 fiber with variable staple length (VCL) developed from an innovative cutting program. With an adequate variation range of the fiber lengths, Alya VCL is able to obtain from the staggered cutting technology it comes closer to cotton staple in terms of staple length distribution (Fig. 3). The issue is how these new fiber properties behave in the spinning process on new high-performance machines, and what results can be expected. For purposes of comparison, the same fiber type was used, but with conventional cut staple. Both types of fiber were also blended 50/50 with carded Brazilian Matto Grosso cotton.

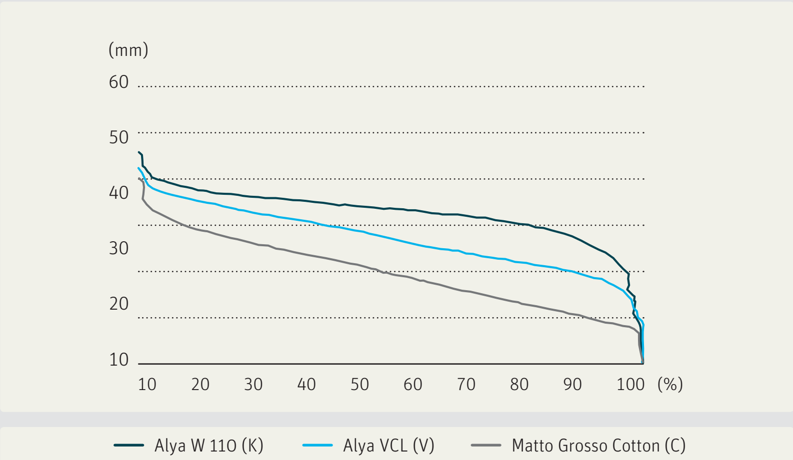

Fig. 3 – Almeter staple diagram

	100% Alya K / V	Blend K + C / V + C
Bale opener / Opening / Cleaning	A 11 + B 33	A 11 + B 33 UNIclean B 11 UNIflex B 60
Card	C 60 + C 51	C 60
Breaker drawframe Finisher drawframe	D 15 D 35 autoleveler	D 15-Blend D 35 autoleveler
Roving frame	F 10	F 10
Ring spinning machine	G 33	G 33

Fig. 4 – Experimental Plan

Following abbreviations were chosen for the three different fibers:

- K = Alya W 110
- V = Alya VCL
- C = Carded cotton (Matto Grosso)

Accordingly the designations of the four positions are:

- K = 100% Alya W 110
- V = 100% Alya VCL
- K+C = 50% Alya W 110 + 50% carded cotton
- V+C = 50% Alya VCL + 50% carded cotton

The basic properties of the two polyester fibers are as follows:

Polyester fiber Alya W 110 bolt

- fiber fineness 1.3 dtex
- fiber length 38 mm
- semi-dull

Polyester fiber Alya VCL

- fiber fineness 1.3 dtex
- fiber length 22 to 38 mm
- semi-dull

EXPERIMENTAL PLAN (FIG. 4)

Since, in the case of the 50/50 PES/cotton blend, the carded cotton still exerts a technologically dominant influence and is a crucial factor for ends down frequency on the ring spinning machine, the 2-passage drafting process was chosen for ring spinning in order to obtain correctly positioned fiber hooks.

SPINNING PLAN 100% VCL AND 100% CONVENTIONAL POLYESTER STAPLE

K = 100% Alya 1.3 / 38 mm V = 100% Alya 1.3 / VCL

Process	Variables	Delivery m/min	Draft	Production kg/h	Count tex
C 51 card C 60 card	Reference Production (+50%) Production (+90%) Card Draft 3 Licker-in	155 155 200 155 155	108x 110x 110x 85x 110x	45 68 88 68 68	4 900 7 300 7 300 7 300 7 300
Drawframe	All card variations	1st Passage 2nd Passage			5 600 (4 900) 4 900
C 60 card + Drafting module	No Passage	155 290	85x 1.95x	85 85	9 500 4 900
	One Passage reg.	450	8x	132	4 900
Roving frame	Twist factor Cradle	α_e 0.65 and α_e 0.75 34.4 mm and 45 mm			590 590
Ring spinning machine	Yarn count Cradle Spindle speed	Ne 28, 36, 50 36 mm and 43 mm 15 000 / 16 500 / 18 000 rpm			21 / 16.4 / 11.8 16.4 16.4

SPINNING PLAN COTTON BLENDS WITH VCL AND CONVENTIONAL POLYESTER STAPLE

K+C = 1.3 / 38 mm + Cotton V+C = 1.3 / VCL + Cotton

Process	Variables	Delivery m/min	Draft	Production kg/h	Count tex
C 60 card Alya / Alya	Production (+50%)	155	110x	68	7 300
Card 60 Cotton	Production (+50%)	160	110x	70	7 300
Drawframe	1st Passage	450	7.5	Blend: 3 sliver PES 3 sliver cotton	5 600
	2nd Passage autoleveler	450	7.1	6 sliver	4 900
Roving frame	Twist factor	Alya 1.3 / 38 mm α_e 0.95 and α_e 0.85 Alya 1.3 / VCL α_e 1.02 and α_e 0.95			590 590
Ring spinning machine	Yarn count Cradle Twist factor Spindle speed	G 33 G 33 36 mm and 43 mm α_e 3.70 and α_e 3.95 K 44 (knit wears)			21 16.4 16.4 16.4 16.4

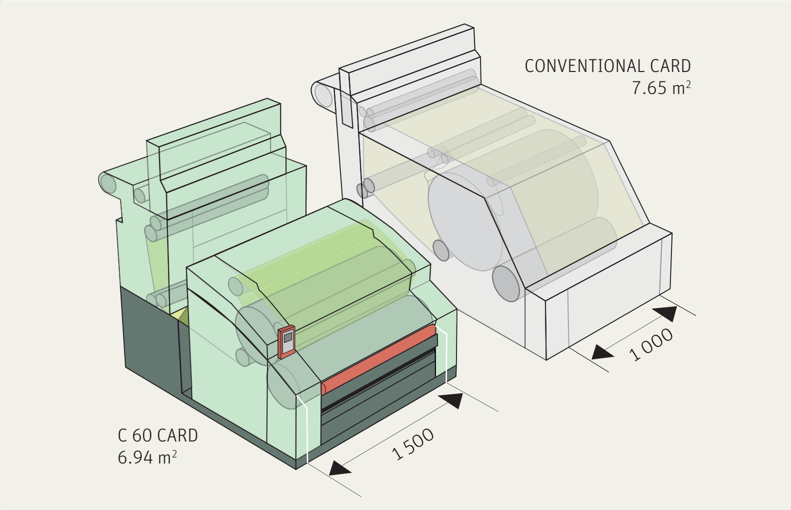

Fig. 5 – Width of C 60 card

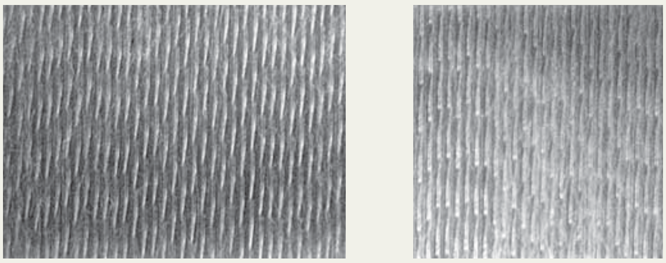

Fig. 6 – Fiber density on cylinder

Fig. 7 – C 60 with drawframe module

PROCESSING CHARACTERISTICS IN CARDING

The card technology C 60 has pushed production limits up to previously unknown levels. The whole geometrical conditions have been altered; e.g. smaller diameter of cylinder and larger diameter of doffer, and especially the width of the cylinders has changed from 1 m to 1.5 m (Fig. 5). This results in a much lower average carding force.

BENEFITS OF THE CARDING TECHNOLOGY

The carding force between cylinder and flats has a big influence on productivity and quality. The mean carding force increases exponentially in relation to card output. If it is also borne in mind that the carding forces during the processing of man-made fibers are up to 10 times higher in comparison to cotton, it also becomes clear what enormous increases in output become realistic by reducing fiber density and thus carding forces. Hence, by working with man-made fibers and the new carding technology the benefit becomes dramatically evident.

If the density of fibers is too high the carding force will increase. Too much carding force results in lower carding quality. The fibers are spread out over a working area of 1.5 m with the C 60. This leads to a lower fiber density, which results in a better carding quality or much higher productivity with the same quality (Fig. 6).

The C 60 card technology is also available with a drafting module. This allows parallelizing of the fiber directly after the carding process when the fibers are mostly in the correct direction to pull out the fiber hooks. Depending on the end spinning system, the raw material and yarn count, this technology allows a shorter spinning process (Fig. 7).

Fiber results

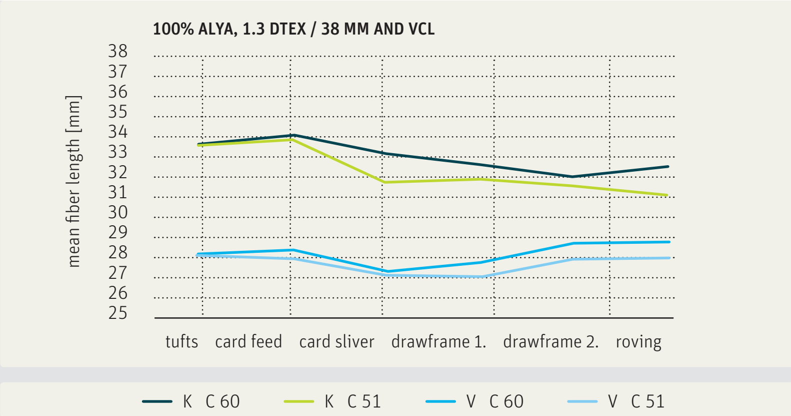

Fig. 8 – Mean fiber length over the process

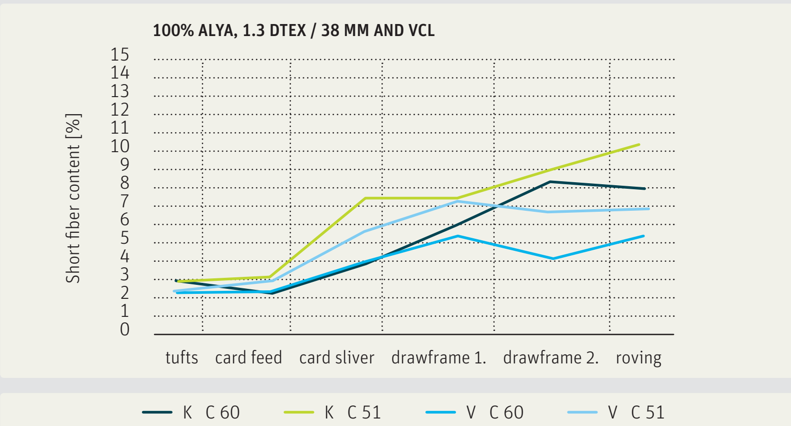

Fig. 9 – Short fiber content <12.5 mm over the process

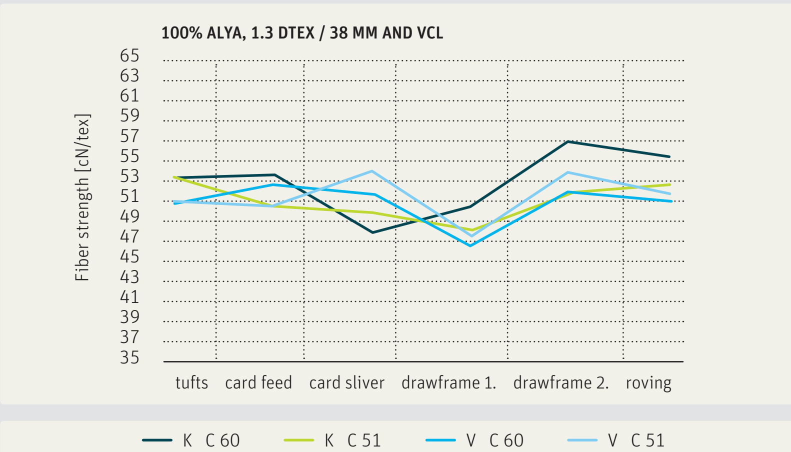

Fig. 10 – Fiber strength over the process

MEAN FIBER LENGTH

There are noticeable differences in mean fiber length between the two fiber types due to the different staple lengths. Compared to the C 51 card, the fibers produced by the C 60 card are approx. 1 - 1.5 mm longer, indicating a gentler carding process (Fig. 8). It should be pointed out when comparing the two generations of cards that the production of the C 60 was already 50% higher due to its larger working width.

SHORT FIBER CONTENT

Despite the variable staple length of VCL fiber, the short fiber content does not differ significantly from PES of conventional staple length. This means that VCL fiber lengths are in an ideal range for the spinning process. On the basis of the short fiber content, the C 60 card displayed lower fiber stress than the C 51 with both types of polyester (Fig. 9). Card clothing and settings certainly have a decisive influence on fiber stress. Comparable basic conditions were created as far as possible in the context of the study. The new carding technology on the C 60 substantially reduces carding force, especially with man-made fibers, due to the lower fiber density, i.e. the distribution of fibers on the surface of the clothing. It can thus be stated that, on the basis of fiber lengths, the C 60 displayed lower fiber stress despite 50% higher card production with both types of polyester compared with conventional carding technology.

FIBER STRENGTH AND ELONGATION

There is no difference in single fiber strength between the two types of polyester, nor was any expected. Taking the individual process stages into account, no differences in fiber strength are apparent, neither between the types of polyester nor between the two carding systems (Fig. 10).

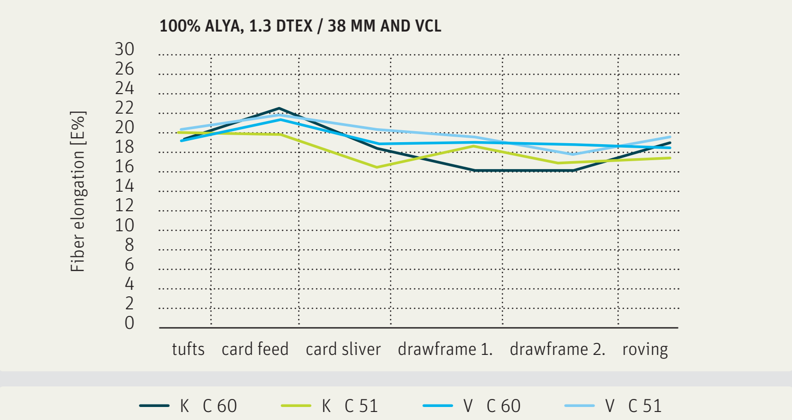

Fig. 11 – Fiber elongation over the process

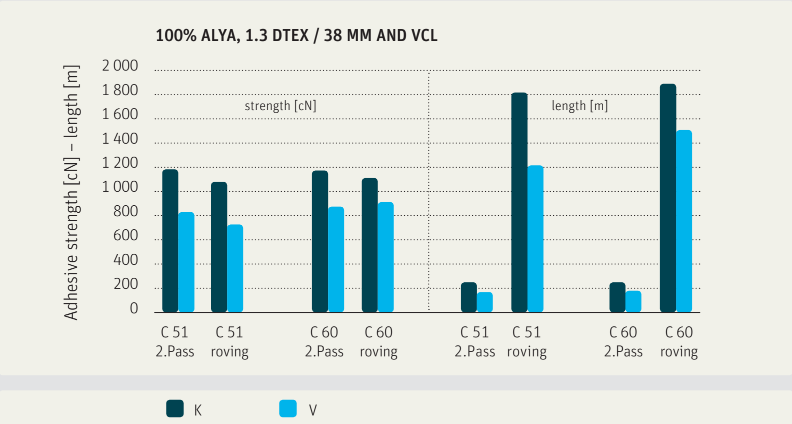

Fig. 12 – Adhesive strength and length (Rothschild)

Fig. 13 – MTDA 3

Elongation values decline over the individual process stages due to fiber stress, but no clear differences are apparent between the two types of polyester and types of cards (Fig. 11).

ADHESIVE STRENGTH

There is a linear decline in removing crimp over the individual process stages due to the drafting action, i.e. parallelization. The two types of polyester and the carding system exert no influence (Fig. 12).

Adhesive strength and adhesive length were defined on the two intermediate products of card sliver and roving. VCL polyester displays 20 - 30% lower adhesive strength and length. This is because of the shorter fiber length and thus to lower fiber adhesion.

This means that the spinning schedule, the machine settings and the technology elements have to be adjusted, especially from the roving frame onwards. Despite differing fiber stress and, therefore, different fiber lengths, the influence of the carding system on adhesive strength or adhesive length is only minimal.

OPENING FORCES

In order to get an indication of the extent to which drafting forces differ between the two types of polyester, the opening force of the fiber material was measured on a modified MTDA 3. (Fig. 13)

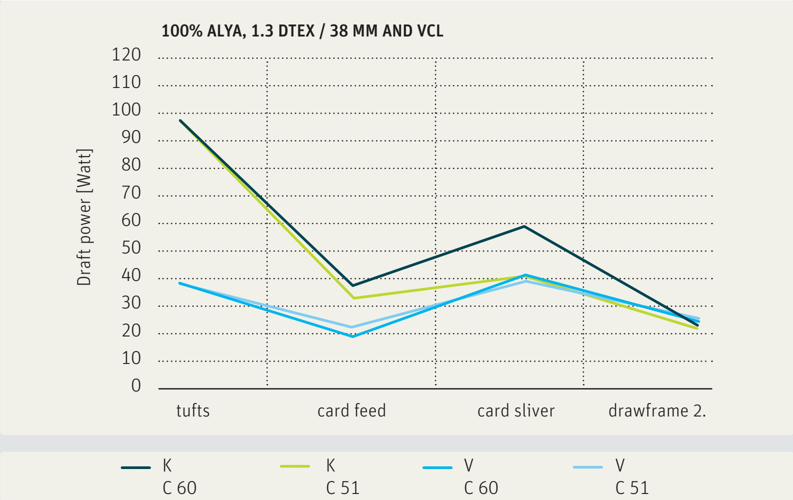

Fig. 14 – Activity input of opening Roller (MDTA 3)

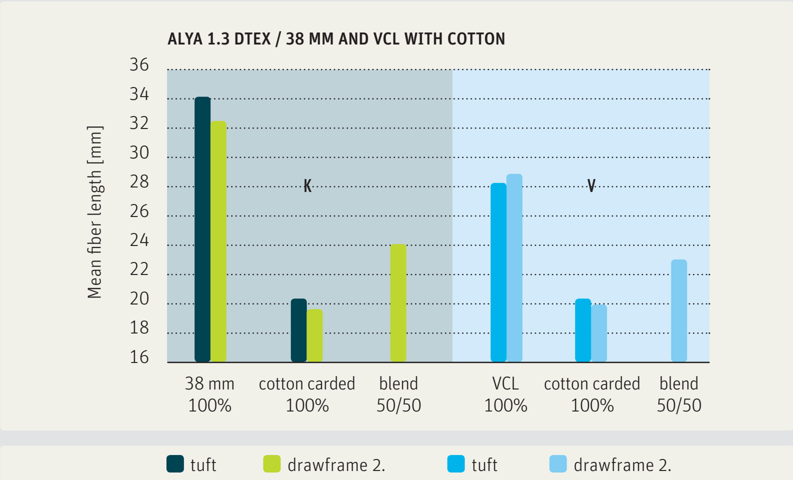

Fig. 15 – Mean fiber length before and after blending with cotton

Following abbreviations were chosen for the three different fibers:
- K = Alya W 110
- V = Alya VCL
- C = Carded cotton (Matto Grosso)

Here the electrical power input was measured in watts at the opening cylinder. Considerable differences in opening force and thus drafting force between the two types of polyester were measured up to the drafted sliver in the second passage (Fig. 14). It should be possible to process VCL fiber better as a result of the shorter fiber lengths, i.e. the specific distribution of fiber lengths, and thus with lower carding forces and drafting forces. The lower processing forces can therefore be regarded as an advantage in terms of spinning technology and should also be reflected positively in yarn evenness and purity.

MEAN FIBER LENGTH

After blending with cotton, the mean fiber length of both types of polyester is between 23 and 24 mm (Fig. 15). When blended with 50% cotton, the mean fiber length after the second drafting passage is in a similar range, regardless of the polyester staple length. From this can be concluded that extreme differences in spinning properties are not to be expected after the drafting passage. Especially in the short fiber content, it is very clearly apparent that the addition of 50% cotton is the dominant feature of fiber characteristic values and therefore influences further spinning properties following the second drafting passage. This means that running properties and physical yarn values will very substantially reduce the differences between the two types of polyester after blending. In the case of this polyester/cotton blend the influence on blending accuracy, i.e. rather uniform dye affinity, should therefore be observed.

IRREGULARITY

No clear differences are apparent between the two types of polyester and the cards with regard to the irregularity of intermediate products such as sliver and roving. Experience has shown that any differences in uniformity usually only appear in the yarn.

Yarn results

100% PES Alya 1.3 dtex 38 mm, (C 60, 2 drawframes, G 33)

100% PES Alya 1.3 dtex VCL, (C 60, 2 drawframes, G 33)

Fig. 16 – Yarn structure, 100% PES

Blend 50/50, PES Alya 1.3 dtex 38 mm + cotton, (C 60, 2 drawframes, G 33)

Blend 50/50, PES Alya 1.3 dtex VCL + cotton, (C 60, 2 drawframes, G 33)

Fig. 17 – Yarn structure, 50/50 PES/Cotton

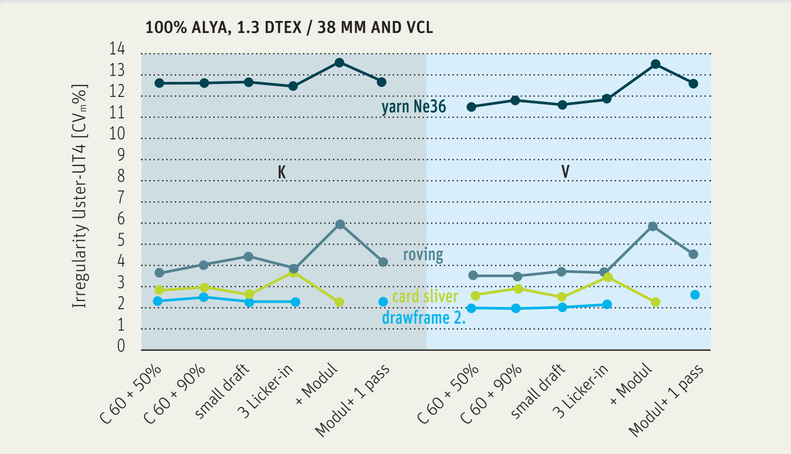

Fig. 18 – Irregularity

YARN STRUCTURE

Optically, no clear differences in the yarn structure are apparent between the two types of polyester fiber. On the other hand, as is already apparent from fiber length measurements, the fiber characteristics are clearly influenced by the addition of 50% Matto Grosso cotton, and this is also clearly reflected in the yarn structure (Fig. 16 & 17).

CARD AND PROCESS VARIABLES IMPERFECTIONS (IPI)

Compared with the polyester of conventional 38 mm staple length, VCL polyester displays 30 - 50% fewer thin places and 7 - 15% fewer thick places in the yarn at yarn counts of Ne 36 - Ne 50. This result is remarkable and, as already explained in the case of fiber characteristic values, is attributable to the better spinning conditions of VCL. No differences are apparent in nep count between the two types of polyester.

The carding performance and quality of the C 60 carding system is equally remarkable. Depending on polyester type and yarn count, thick places were reduced by 5 - 20% and neps by 20 - 30%, despite 50% higher card production compared with the conventional carding system. From this it can be concluded that carding production on the C 60 with these fibers can still be increased considerably while maintaining very good yarn quality.

IRREGULARITIES

At a yarn count of Ne 36, VCL polyester displays yarn irregularity up to 9% better than that of conventional 38 mm staple length. As already concluded on the basis of the fiber characteristic values, VCL makes a positive impression on yarn irregularity because of its staple length distribution and favorable processing characteristics over the individual process stages (Fig. 18).

Looking at yarn irregularity in the different versions of the spinning process, following findings are revealed:

- With the C 60 carding system, card production was increased to 88 kg/h without any adverse impact on quality. Compared with the conventional carding system operating at 45 kg/h, therefore, this results in an increase in production of almost 90%. This production increase has to be seen under condition that fine and first class quality yarns were produced.
- At a feed lap weight of 800 g/m on the C 60 card, drafting was reduced from 110-fold to 85-fold. A reduction in feed lap weight had no influence in this range, i.e. yarn quality could not be improved further in this way.
- The C 60 carding system is modular in design, enabling 1 or 3 licker-ins to be used, depending on the customer‘s requirements. Irregularity values for both types of polyester show that the results achieved with a single licker-in could not be improved upon.
- The carding system is designed so that the slivers can be optimally and flexibly adjusted to the ideal sliver count with a drafting system module immediately following the card. This enables, for example, shortening the process or even improvement of the yarn quality, depending on the specific application.

It can thus be established that two conventional drafting passages are ideal for both types of polyester; the second one, of course, must be an autolevelling drafting passage.

IMPERFECTIONS

Yarn purity also emerges clearly in favor of VCL polyester with the process variables studied. The finer the yarn, the more clearly evident are the influencing parameters originating from fiber preparation and the raw material. The statements made up to now regarding card production, draft distribution, number of licker-ins and process sequence relating to yarn irregularity, are also confirmed by the results for thin and thick places.

The nep count only rises
- by reducing the draft
- by using the 3 licker-in system
- at yarn counts above Ne 50 in combination with the 38 mm polyester.

However, by increasing card production these neps are evidently primarily neps that can be mechanically opened and can be eliminated again by selecting the appropriate drafting process.

YARN STRENGTH

VCL polyester displays approximately 5 - 10% lower yarn strength than polyester of conventional 38 mm staple length. The decline in strength is physically given due to the shorter fiber length distribution similar to that of cotton. Nevertheless, the yarn strength is in a high range that is normal for polyester fibers (Fig. 19).

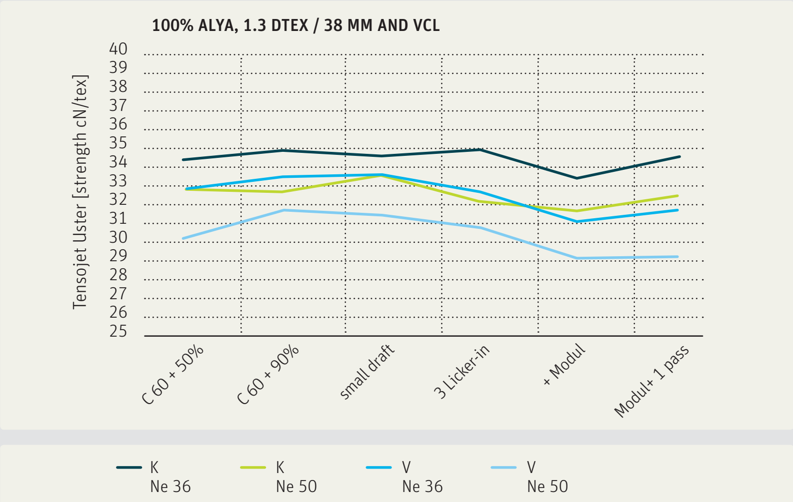

Fig. 19 – Yarn strength

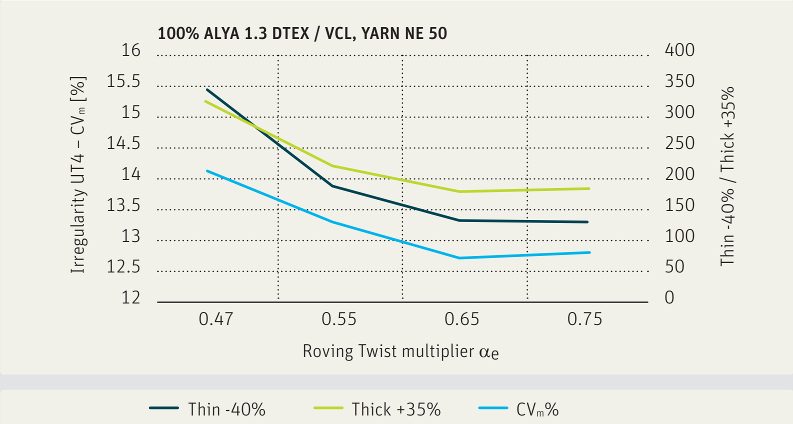

Fig. 20 – Yarn quality depending from roving twist multiplier

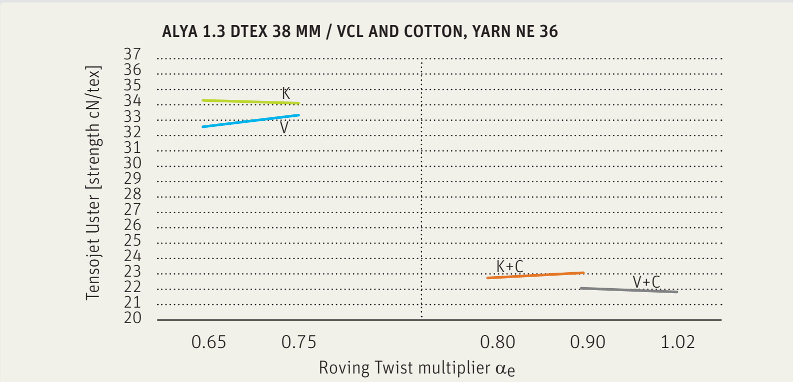

Fig. 21 – Yarn quality depending from roving twist multiplier

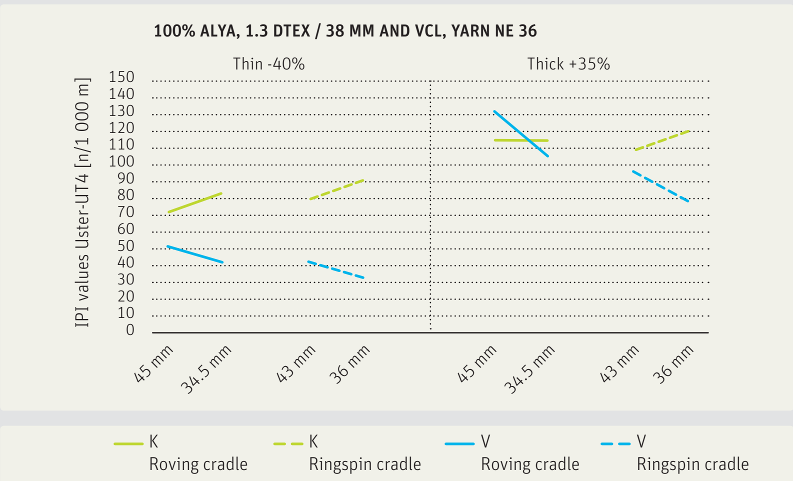

Fig. 22 – Yarn quality depending from roving and ringframe cradle

From this can be concluded that in the case of VCL polyester the roving twist and fiber control on the roving frame and ring spinning machine must be adjusted compared with conventional 38 mm cut staple. The finer the yarn, the lower the yarn count related strength; this is due to the declining number of fibers in the cross section of the ring-spun yarn.

Yarn strength was maintained at a very high level in both types of polyester, despite increasing card production to 88 kg/h. The feed lap weight and the triple licker-in had no influence. The conventional process with two drafting passages must also be recommended for both types of polyester on the basis of the strength values.

ROVING AND RING FRAME VARIABLES

INFLUENCE OF ROVING TWIST

Optimum roving twist was determined by final yarn spinning with VCL polyester. VCL fiber indicate ideal roving twist in the range of α_e 0.65 - 0.75 (Fig. 20).

On the basis of fiber/fiber friction in polyester of conventional 38 mm staple length, the optimum twist factor should therefore be < α_e 0.75. In case of VCL polyester blended with 50% cotton, the roving twist can therefore be increased to α_e 1.02. For polyester of 38 mm staple length with 50% cotton added, the optimum twist factor of the roving is α_e 0.8. - 0.9 (Fig. 21).

The mean fiber length displayed a similar average staple for both types of polyester after blending with cotton. Nevertheless, the optimum roving twist factor for VCL type polyester blended with 50% cotton is higher than for polyester with a staple length of 38 mm.

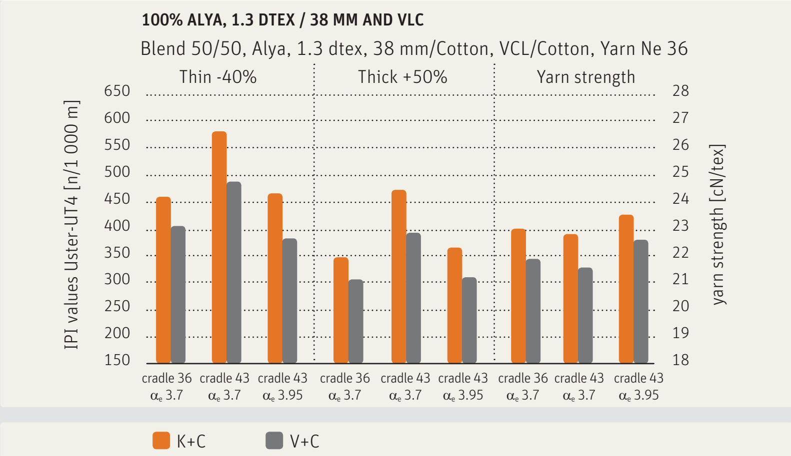

Fig. 23 – Yarn quality depending from ringframe cradle and yarn twist

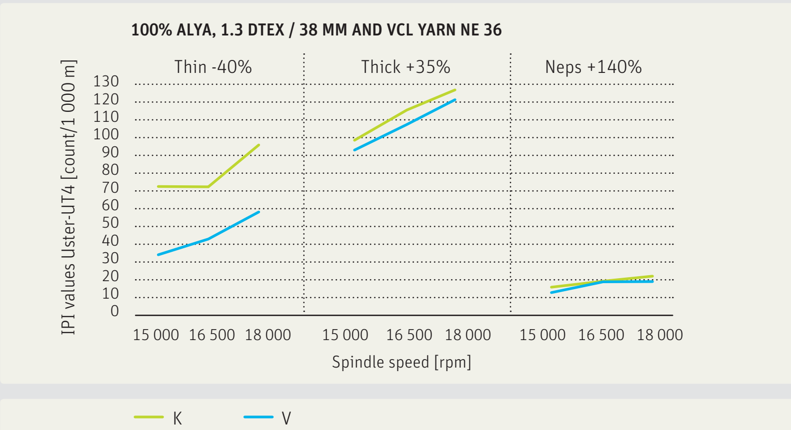

Fig. 24 – Yarn quality depending from spindle speed

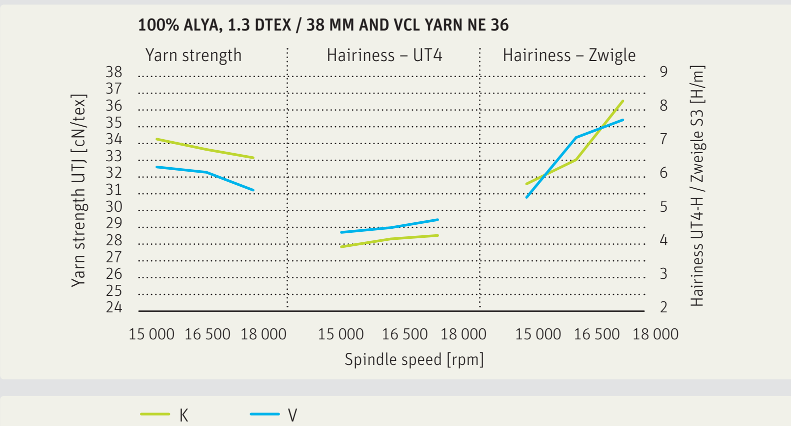

Fig. 25 – Yarn quality depending from spindle speed

INFLUENCE OF CRADLE

When processing 100% polyester of 38 mm staple length, the longer cradle (43 or 45 mm) should be used both on the roving frame and on the ring spinning machine for optimum fiber control in the drafting system. When processing 100% VCL polyester, the shorter cradle (34.5 or 36 mm) should be used due to the fiber length distribution (Fig. 22).

In the case of blends with cotton, the smaller cradle (36 mm) on the ring spinning machine proves more favorable for both types of polyester. From this, it can be concluded that the shorter cradle (34.5 mm) is also more favorable for the roving frame with regard to yarn purity (Fig 23).

INFLUENCE OF SPINDLE SPEED

Higher spindle speeds result primarily in an increase in thin and thick places in both types of polyester. (38 mm staple length and VCL) (Fig. 24). The advantages of VCL are also clearly apparent here. Yarn strength declines and hairiness increases with rising spindle speeds (Fig. 25).

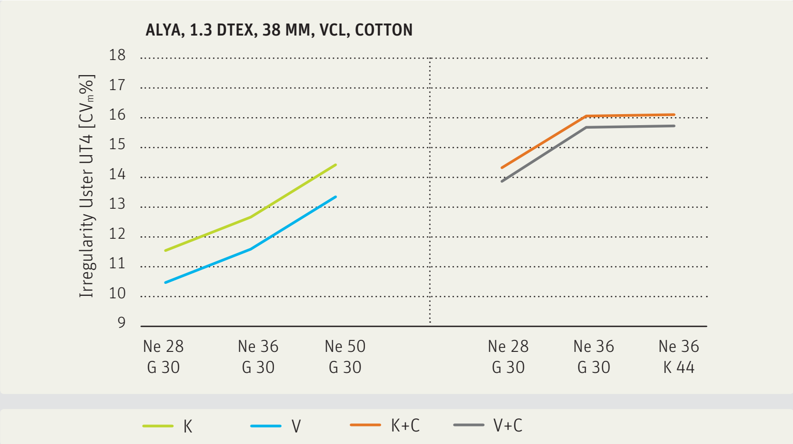

Fig. 26 – Yarn quality depending from yarn count and ringspinning system

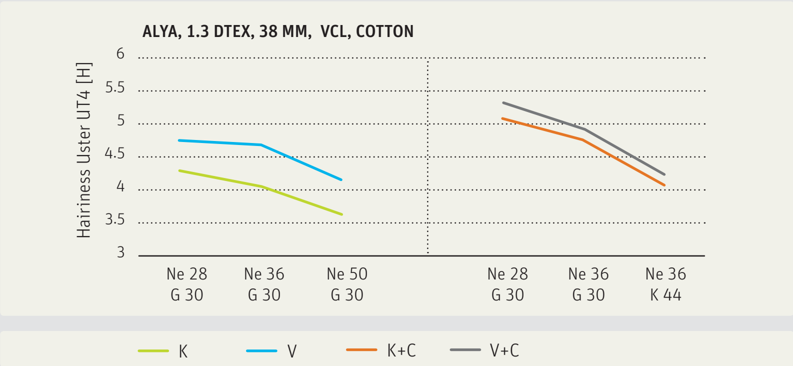

Fig. 27 – Yarn quality depending from yarn count and ringspinning system

YARN QUALITY DEPENDING FROM YARN COUNT

Irregularity increases as the yarn becomes finer, with VCL polyester displaying irregularity that is approx. 9% better than conventional 38 mm cut staple. If 50% cotton is added, the differences are only very minimal (Fig. 26).

HAIRINESS

In the case of VCL, hairiness is approx. 10 - 13% higher than for conventional cut staple due to the shorter fiber lengths. In the case of blended cotton the values increase sharply due to the higher short fiber content and show only minimal differences between the two types of polyester (Fig. 27).

The ComforSpin system features non-wearing technology components such as a perforated drum, suction inserts and air guide elements. Depending on the raw material and the number of fibers in the cross section, respectively the yarn count, the technology components and settings differ for achieving the best possible compacting result. Using the Com4® system enables hairiness in the polyester / cotton blend to be reduced by approx. 14%.

SUMMARY

The VCL fiber has several advantages; one of them is its ability to be easily processed with the C 60 card. Over the whole spinning process equal or better values for sliver and roving were achieved. Thanks to the similar staple of the VCL fiber with the cotton staple a homogeneous staple distribution for blends with cotton 1 1/8″ (carded) is the result, leading to a better overall yarn quality. Compared to conventional cut polyester staple, with the VCL fiber the sliver strength of the carded and drafted sliver is slightly lower. Roving strength with the same twist is approx. 15% lower; therefore, a higher twist (+10%) may be necessary. Yarn hairiness (Uster + Zweigle) is with 100% VCL moderate and with blends it is slightly higher. Yarn strength is about 5% lower, which is in a range that should not have a negative effect on the further processability of these yarns.

Compared with the conventional carding system, card production was increased with the C 60 carding system by 95% without any adverse impact on quality. Despite the huge increase in card production of 95%, yarn strength is in the same range or is even better. Using the C 60 card also had a positive impact regarding short fibers, here the short fiber content turns out lower.

The best results with these polyesters and 50/50 polyester carded cotton blends were recorded with the C 60 without drafting module and two drawframe passages. Both single and triple licker-in lead to the excellent yarn results.

One of the conclusions of this trial is, for processing conventional polyester staple fibers and the new VCL fibers the C 60 is the ideal card. An advantage of the Com4® system is that it enables in case of polyester – cotton blending 14% less yarn hairiness compared to the conventional ring spinning system.

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