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Processing of Viscose Fibers

Processing characteristics of viscose fibers from South Pacific Viscose (SPV) on Rieter rotor spinning machines

Processing of SPV* Viscose on R 40 Rotor technology

PREFACE
Out of a global production of 40 million tons of filament and staple fiber, cellulosic staple fiber production accounts for 7% (Fig. 1). Relative to manmade staple fiber production alone, the proportion of cellulosic staple fibers is therefore already 15.8%.
With an annual production of about 20 million tons, cotton production remained more or less constant over the years. Last year's production rate increased to 26 million tons, which seems to be a new record. With about 14 million tons synthetic fibers rank as number two. Production of cellulosic fibers has regained strength and currently reaches a capacity of about 2.7 million tons. (Fig. 2).

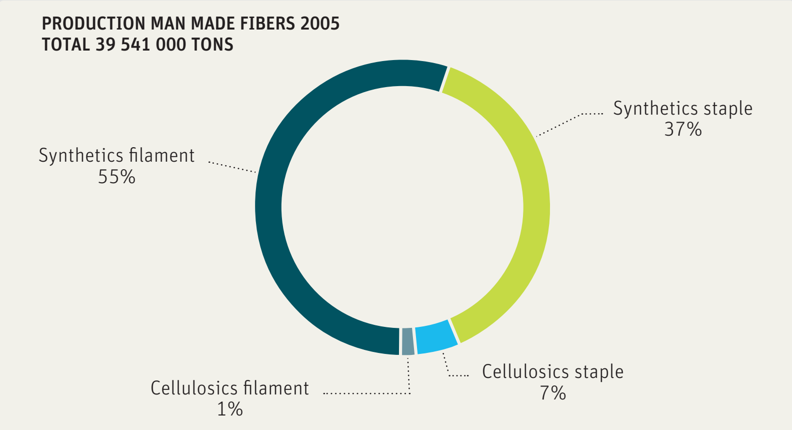

Fig. 1

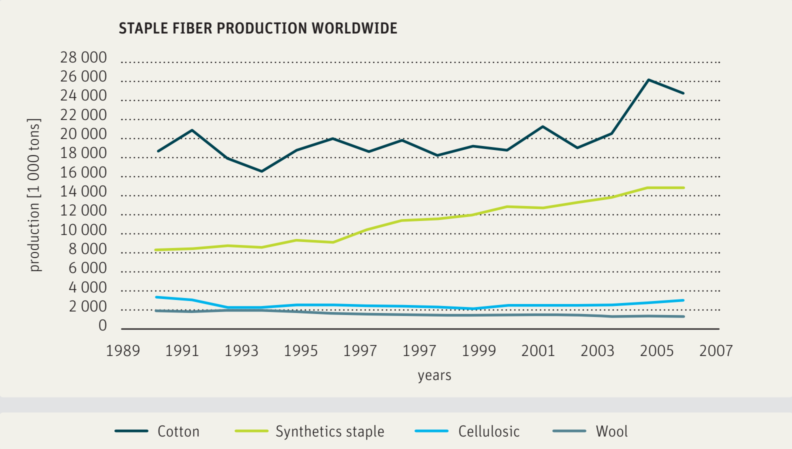

Fig. 2

PROPERTIES OF CELLULOSIC FIBERS
Viscose
- Dry strength 22 - 25 [cN/tex]
- Moisture absorption (higher than cotton)
- Permanent antistatic properties
- Brilliant colors

Modal
- Dry strength significantly higher compared to viscose fibers 34 - 36 [cN/tex]
- Improved wet strength
- Moisture absorption (higher than cotton)
- Higher fiber strength allows the production of micro-fibers
- Designed for the production of luxurious fabrics
- Permanent antistatic properties etc.
- Soft to wear

TENCEL®
- Further improvement of the dry strength 36 - 40 [cN/tex]
- Excellent moisture management
- Highest wet strength of all cellulosic fibers (80% of the dry strength)
- Improved dimension stability of the fabrics
- Designed for the production of high fashion fabrics
- Manufacturing process is extremely environmentally friendly

Cellulosic fibers such as viscose, modal, and TENCEL® have developed their specific market segments in 100% as well in blends with fibers like cotton, polyester etc. They are well established in high fashion fabrics, in leisure wear, in casual fabrics, in underwear as well as in a wide range of home textiles to name just a few typical end uses.

* Member of the Lenzing Group

The wear properties of fabrics made of cellulosic fibers are often superior to those of 100% cotton or 100% synthetic fabrics .Their softness is highly valued in fabrics or garments worn next to the skin. Especially Modal and TENCEL® fibers reveal softness and optimized moisture management. Fiber blends will often help to improve the functionality of fabrics. In active sportswear, for example, fabrics with a two-layer construction help to overcome the problem- of heavy perspiration. An inner layer of synthetic fibers helps to quickly transport the moisture away from the body. The outer layer of the fabric of cellulosic fibers or blends containing cellulosic fibers absorbs the moisture and releases it into the atmosphere. As demonstrated in figure 3 fibers like Cotton, Viscose, or Modal take up moisture into the fiber in a way that clusters or pockets where moisture is concentrated can be found. In contrast to other Cellulosic fibers TENCEL® fibers take up moisture very evenly throughout the fiber as shown. On synthetic fibers moisture is concentrated on the surface of the fibers contrary to Cellulosic fibers. These different mechanisms of moisture uptake can be used in optimizing the moisture management capabilities of fabrics by using man made cellulosic fibers, most preferred TENCEL® fibers.

Cellulosic fibers are famous for their processing performance. They easily match the requirements of high speed spinning technologies to be successful in a highly competitive market. In recent years a dramatic increase in the number of open end spinning machines which process cellulosic fibers – especially viscose fibers – has been recognized. This trend was particularly visible in Asia. Due to this market trend we wanted to evaluate the processing characteristics of Asian viscose fibers on open end spinning machines which represent the latest status in the technology of this spinning method.

SPV VISCOSE PROCESSING ON MODERN HIGH-PERFORMANCE SPINNING MACHINES

As we know the raw material as well as the spinning technology play a decisive role in yarn production. Ultimately, the combination of the best fibers and the best spinning technology is responsible for the yarn parameters and the economy of the spinning process. The spinning process – whether ring, rotor or air – combined with the optimum machine configuration affects without any doubt the subsequent properties right through to the finished textile, as well as the economy of the yarn production. The following study sets out to clarify these relationships. The aim of the joint project between Rieter and Lenzing is to support our common customers in their product development where they are using cellulose fibers and modern high-performance spinning machines.

MOISTURE ABSORPTION H_2O = BLACK, CELLULOSE = WHITE

Cotton Viscose Modal TENCEL®

Fig. 3

TENCEL® LF 0.9 dtex, 34 mm, Yarn count 15 tex

C 60 card ring yarn conventional, α_m 110

C 60 card rotor yarn, α_m 110

Fig. 4

TEST PARAMETERS

The viscose fibers selected were an SPV viscose fiber in 1.3 dtex with 38 mm cut length and for comparison, a viscose fiber from an Asian producer identical in fiber fineness and cut length. Processing was performed on the latest generation of Rieter high-performance machines.

- C 60 card, production 80 kg/h
- SB-D 15 drawframe
- RSB-D 40 drawframe, sliver 5 000 tex
- R 40 rotor spinning machine, yarn count Ne 30 / Nm 50 / 20 tex

Processing of viscose fibers on the rotor spinning machine is especially advantageous. Rotor yarns generally produce a rather harsh feel of the fabric due to the “wrap fiber” structure (Fig. 4) whereas rotor yarns from viscose fibers produce a fabric with a much softer and more pliable touch compared to open end yarns from other fibers. The combination of viscose fibers and rotor yarn ultimately also guarantees an excellent pilling performance in knits. The high production speeds offered by the rotor technology is the basis for the excellent economy of this spinning technology.

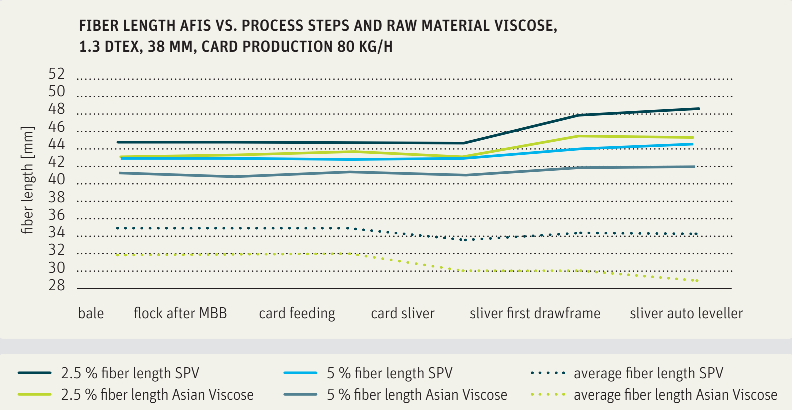

Fig. 5

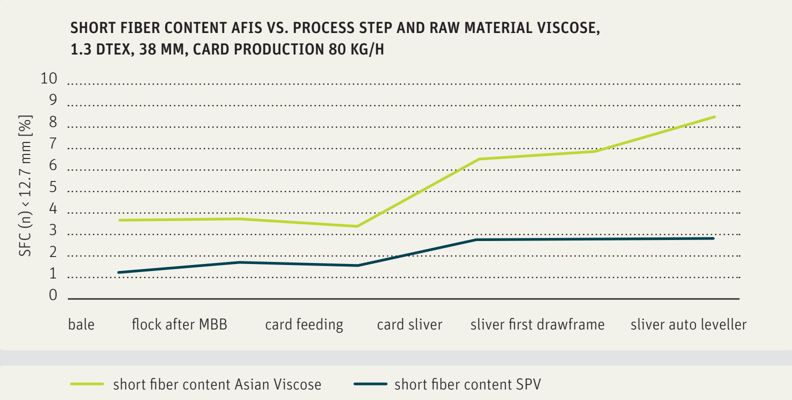

Fig. 6

RAW MATERIAL RESULTS ON THE INTERMEDIATE PRODUCT

Results on intermediate products are clear indication for processing conditions, as well as for the yarn quality which could be expected. The two viscose types show significant differences in their fiber length despite the same cut length specification of 38 mm. SPV viscose fibers are significantly longer than the fibers of the competitor which is evident in a medium staple which is approximately 3 mm longer prior to the card feed. As a result of the parallelization and de-crimping of the fibers, the percentage of longer fibers increases after carding. In contrast, the mean fiber length decreases slightly after carding due to a higher percentage of short fibers (Fig. 5). The content of short fibers depends as well on the stress applied to the fiber during carding and the fiber strength. For the SPV fiber, only a minimum increase of short fibers by about 1.5% has been found. In contrast to the SPV viscose, for the Asian viscose fiber a significantly higher increase of the short fiber content from 4% to 8.5% was found. As we will see later, a high content of short fibers and the substantially greater increase after the carding process will have a negative impact on yarn strength and elongation (Fig. 6).

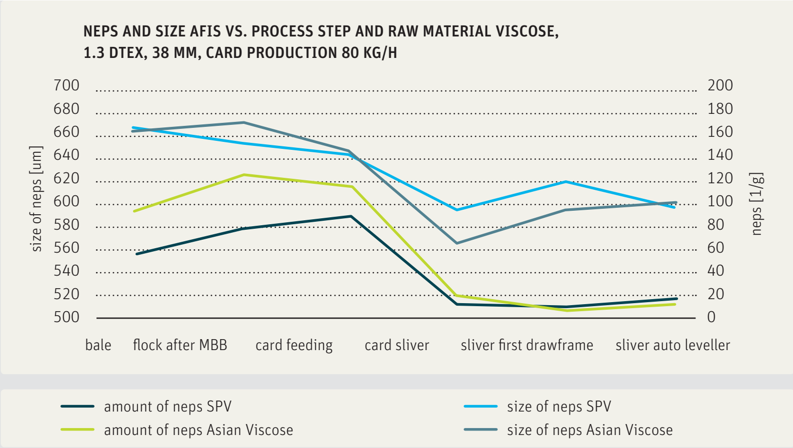

Fig. 7

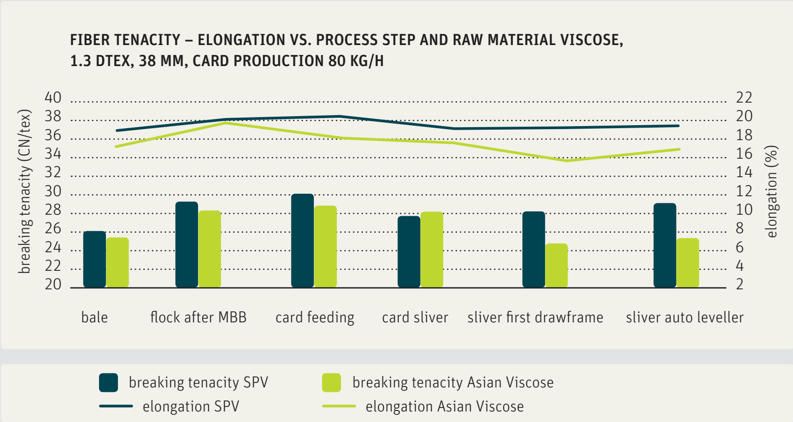

Fig. 8

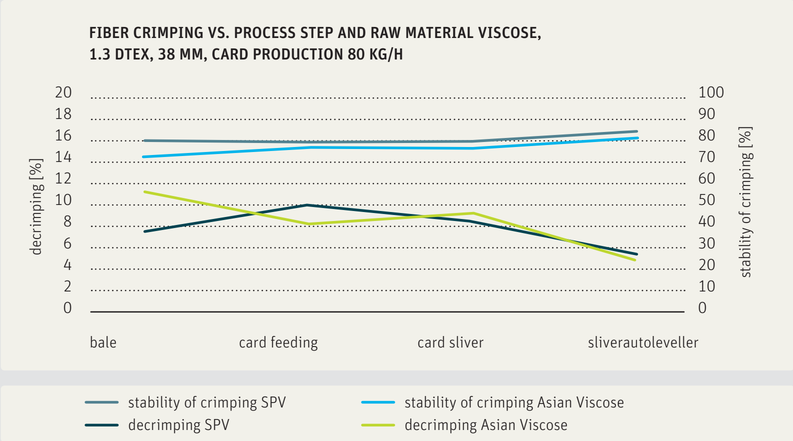

Fig. 9

Without any doubt the C 60 card has achieved an outstanding reduction in neps of around 90% for booth viscose types. Despite a significantly higher nep value for the Asian viscose, differences between the two viscose types are no longer evident after the breaker passage in drawing. The conditions required to produce yarns with an excellent nep value are therefore evident (Fig. 7).

The higher fiber strength and elongation for the SPV viscose allow the conclusion that this is at least one reason for the very small increase in short fibers of just 1.5% after the C 60 card. Fibers of lower strength and elongation, as the Asian viscose, are therefore more susceptible and sensitive to fiber shortening related to the stress applied to the fibers during the carding process. Based on this finding it can be concluded that the card production of 80 kg/h for the SPV fibers could easily be increased to an even higher level. (Fig. 8).

The amount of crimp between the bale and the finisher drafting sliver is reduced through the drawing-out of the fibers as a result of parallelization. Between the two types of viscose fibers, we have not detected differences in de-crimping and in the stability of the crimp (Fig. 9). The adhesion length in the sliver is smaller with the SPV fiber despite a higher mean fiber length and the same crimp. However, the reason for the differences is likely to be found within the different fiber characteristics. The greater adhesion length, please without partition. of the sliver of the Asian viscose could therefore be explained by:

- a smaller degree of parallelization of the fibers
- a greater fiber-fiber friction
- a different fiber cross-section

The evenness values at the breaker passage on the draw frame are slightly different between the two viscose types as a result of different fiber properties. However, the great effect on the uniformity of the sliver through a second RSB-D 40 autoleveled finisher passage removes any differences between the two viscose types in respect of evenness. Generally, there is a direct relationship between the evenness in the sliver and the degree of parallelization. Better parallelization of the fibers usually leads to greater evenness of the sliver. Of course, crucial is the evenness or unevenness immediately before the final spinning machine (Fig. 10).

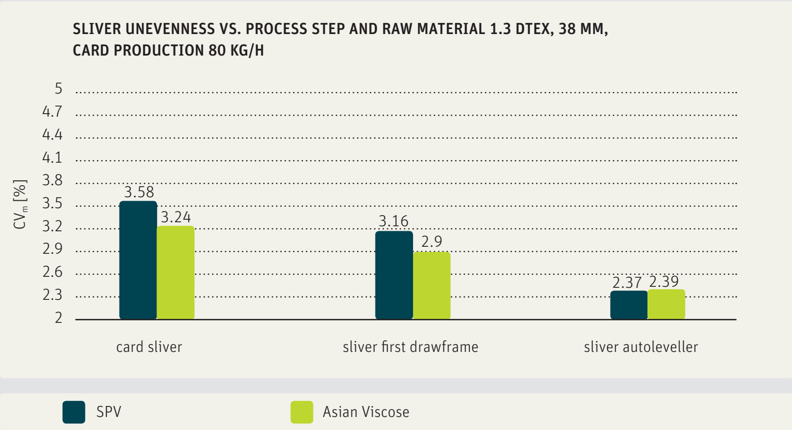

Fig. 10

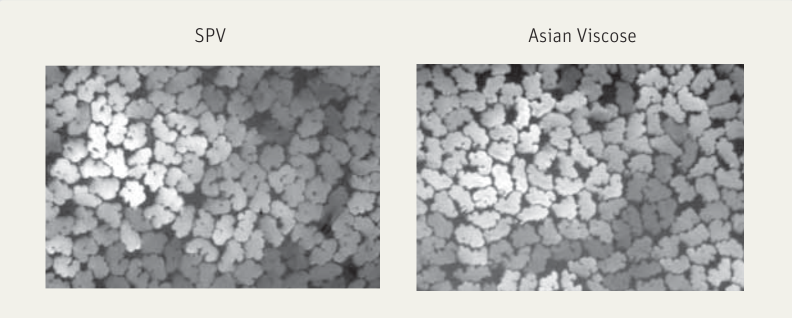

Fig. 11

A microscopic evaluation of the SPV and the Asian fiber shows a difference in the cross-section between these two fiber types. Different cross sections of fibers combined with a different fiber finish can seriously influence the fiber – fiber friction. As a consequence the processing characteristics as well as the yarn quality of fibers from different sources can be influenced severly. (Fig. 11).

Tests of the raw material on the basis of a few important characteristics have shown that clear differences exist despite the same raw material name, an identical fiber fineness and cut length. Therefore differences in the processing characteristics on the final spinning machine have to be expected for the yarn quality and the appearance of the final fabric. On the rotor spinning machine, suitable technological elements can be installed to exert a fundamental influence on the processing performance, the yarn quality and the final textile product.

YARN RESULTS

Besides the raw material characteristics and the fiber preparation, yarn properties are essentially determined by the yarn structure and the spinning process. As already mentioned in the introduction, the combination of the viscose fibers and the rotor spinning process offers a great potential to achieve excellent yarns with optimal economy (Fig. 12).

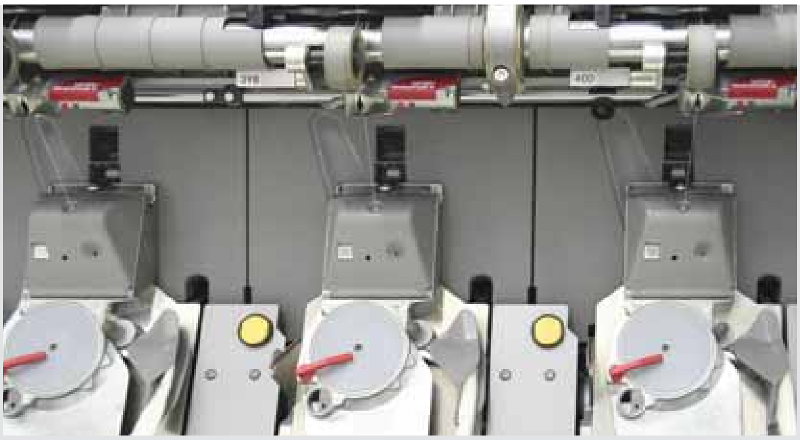

Fig. 12

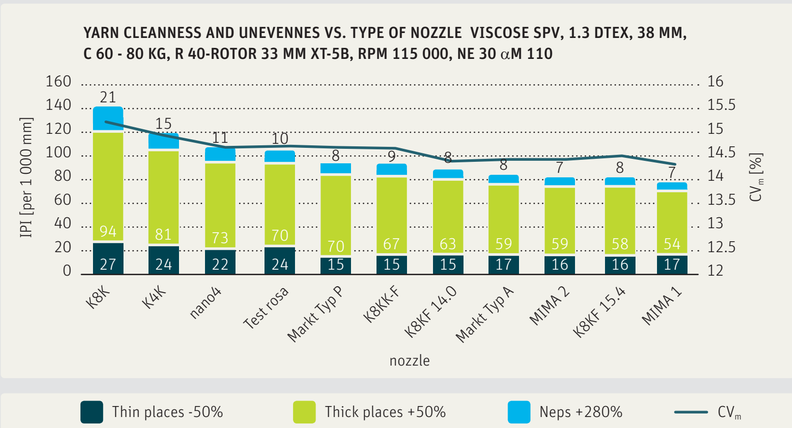

Fig. 13

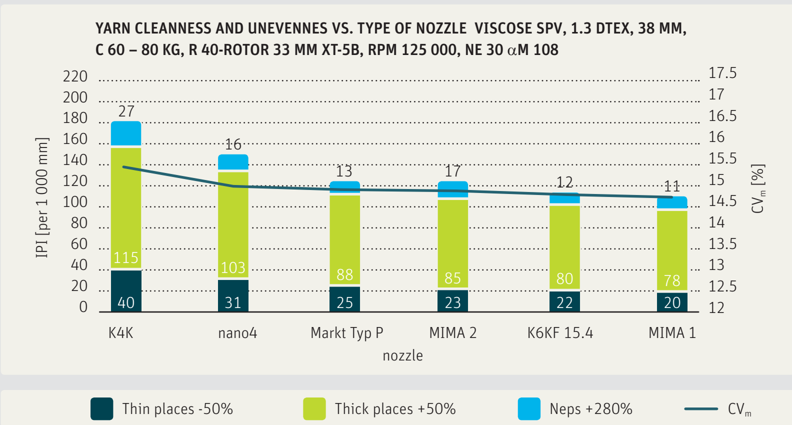

Fig. 14

Consequently we have to ask the question how the technological elements offered by the R 40 spinning machine influence the spinning process and which combination of technological elements offers the best yarn quality and spinning performance. Determining factors are the technological elements, i.e. the nozzles, the rotor and opening roller type and their settings. The variety of nozzles on the market is well known, but through a lack of systematic investigations or the effort associated with this, there are few precise recommendations available for the processing of viscose fibers. Our study consequently compares the nozzles typically used for the processing of viscose fibers and those still in the process of development. Based on an optimum sliver quality the latest nozzle developments MIMA 1 and MIMA 2 produce the best yarn cleanness and consequently also the greatest yarn evenness. These results have been confirmed independent of the type of viscose fiber, rotor speed, rotor diameter and twist factor. Based on the selection of the optimal nozzle , the yarn cleanliness in viscose processing can be improved by up to 50% according to rotor speed (Fig. 13 + 14).

Independent of the type of viscose processed, modifications of the twist factor showed practically no influence on the yarn quality. The type of nozzle and the type of viscose raw material primarily affects the yarn cleanliness, as already mentioned. As a result of other important criteria, it might be necessary to accept compromises in the choice of nozzles for a given raw material. The best yarn values achievable with a specific nozzle are of little use if, as a result of the chosen nozzle, the customer experiences drawbacks in the running performance of the machine which could cause a deterioration in the economic efficiency of the spinning process (Fig. 15 + 16).

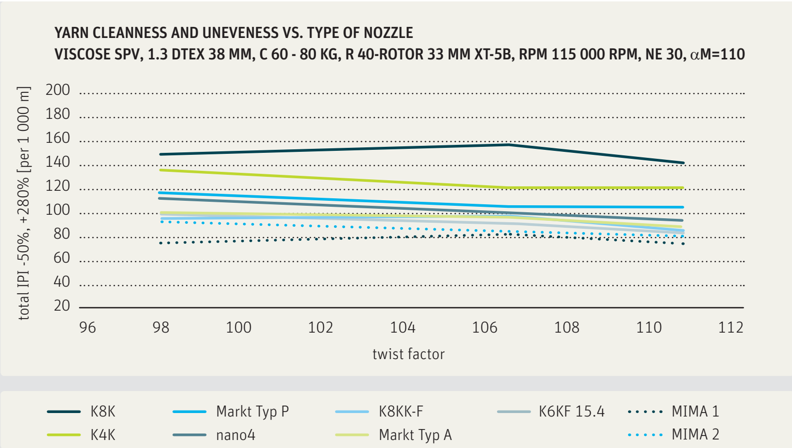

Fig. 15

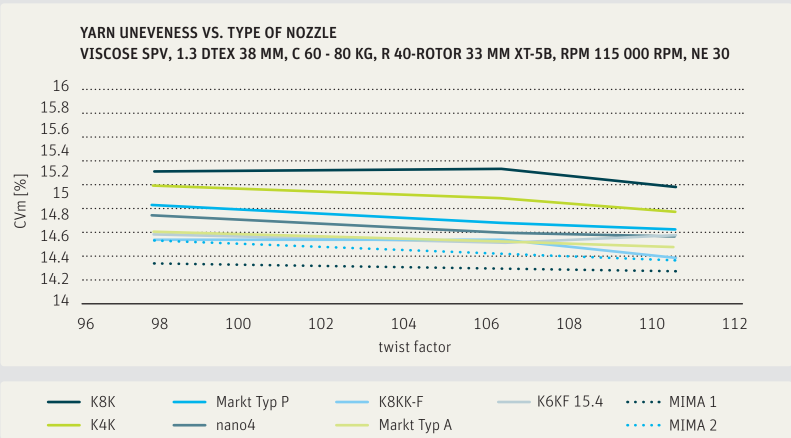

Fig. 16

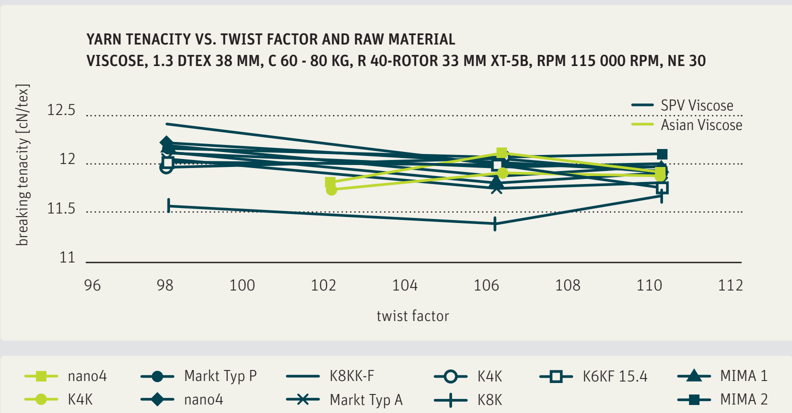

Fig. 17

Due to the properties of both viscose fibers the yarn strength could not be improved by an increase of the yarn twist. A twist factor of αm 105 (α_e 3.5) therefore be recommended to achieve the optimum strength and the best fabric handling properties. It also has been proven that nozzles can affect the absolute yarn strength by up to 0.7 cN/tex (Fig. 17).

As already expected, the elongation for the yarns produced from SPV viscose is higher due to the greater fiber elongation (Fig. 18). Consequently, the working capacity in the yarn differs between the two viscose variants under otherwise identical conditions such as:

- number of fibers in the cross-section
- yarn count
- spinning method
- spinning elements
- settings.

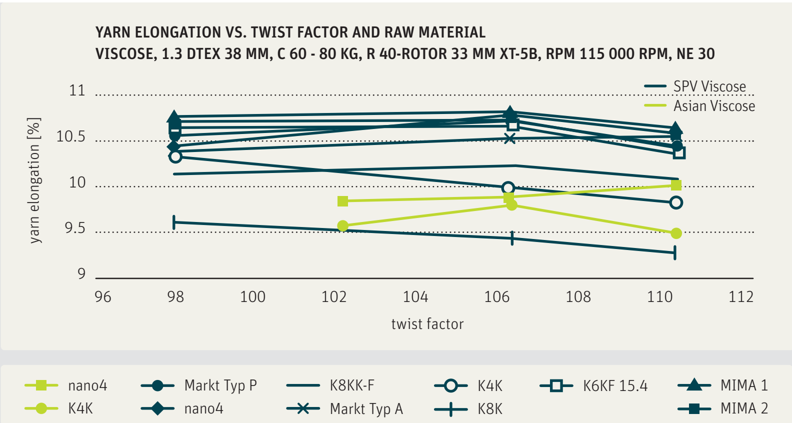

Fig. 18

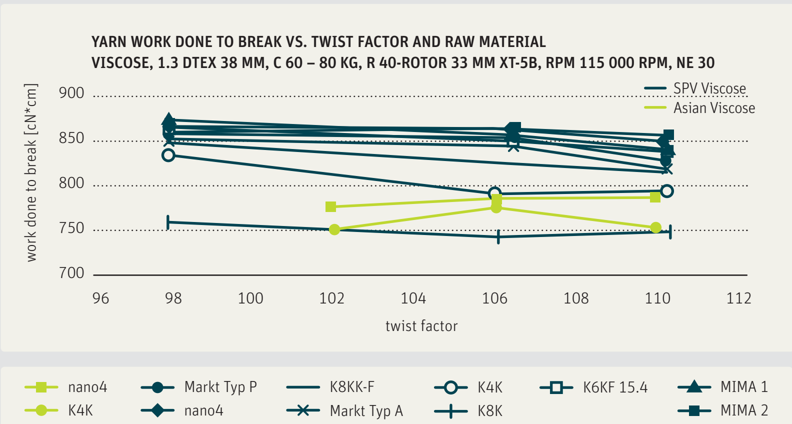

Fig. 19

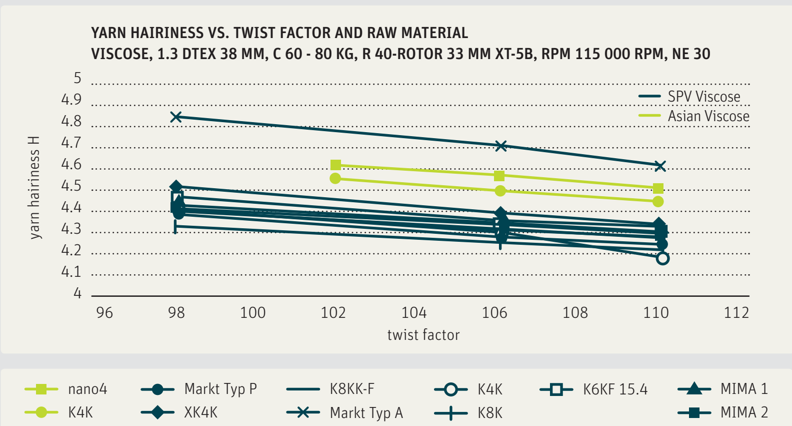

Fig. 20

Yarns from SPV viscose show a working capacity which is about 10% higher than that of the yarn from Asian viscose. A higher working capacity in the yarn is of advantage to match the increased spinning tension caused by high rotor speeds (Fig. 19).

Twist factor, nozzle and viscose raw material have a significant effect on the hairiness values. Taking into account the effect of the nozzles, better fiber integration was achieved with the SPV viscose than with the Asian viscose.

Depending on the intended applications in the further processing of the yarn, lower yarn hairiness has a positive effect on pilling behavior and fiber abrasion. (Fig. 20).

NEW CERAMIC MATERIAL

- Very smooth surface
- For weaving and knitting
- For coarse and finer yarn counts
- For 100% CV, possible CO, PAC, CO/PES
- Compare to K4K
  - Better yarn quality
  - Better spinning stability
  - Higher productivity (+6%)

Fig. 21

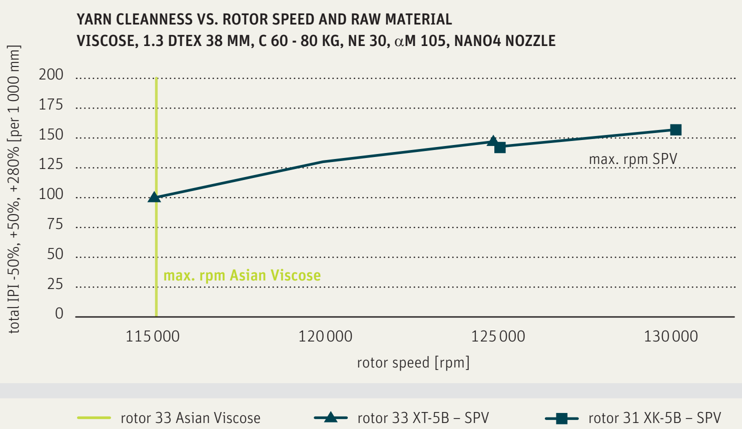

Fig. 22

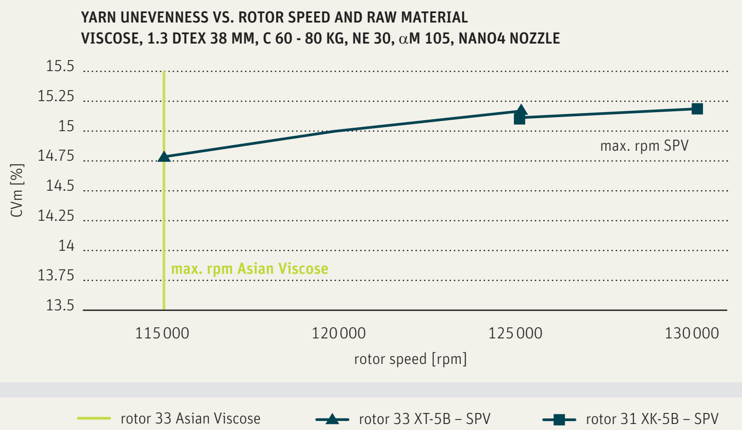

Fig. 23

ROTOR SPEED AND ECONOMIC EFFICIENCY

In our study, the nozzle which was most favorable in terms of the running performance on the rotor spinning machine was tested for both viscose types. The choice of nozzle also required small compromises in yarn quality. Irrespective of the viscose raw material, twist factor, rotor type and diameter, the recently developed „nano4“, „MIMA 1“ and „MIMA 2“ nozzles proved to be the optimal solution. In respect of the best yarn cleanliness, the “MIMA 1” and “MIMA 2” types of nozzle deliver excellent figures but we have to accept that we had to reduce the rotor speed slightly to achieve this result (Fig. 21).

The maximum rotor speed of 130 000 rpm with a level of yarn breaks below 200 yarn breaks / 1 000 rotor hours has been achieved on the R 40 by using the nano4 nozzle in combination with a rotor diameter of 31 mm and with SPV viscose fibers.

Further increases in rotor speed with even smaller rotor diameter are possible but we have to bear in mind the effect of extreme rotor speeds to the feel and the appearance of the final fabric.

For the Asian viscose, an increase in rotor speed above 115 000 rpm could not be achieved with acceptable yarn breakage rates, despite a smaller rotor. Depending on the combination of viscose raw material, modern machine technology and yarn fineness, the example shows that the increase in maximum rotor speed can quite easily be >13 % (Fig. 22 + 23).

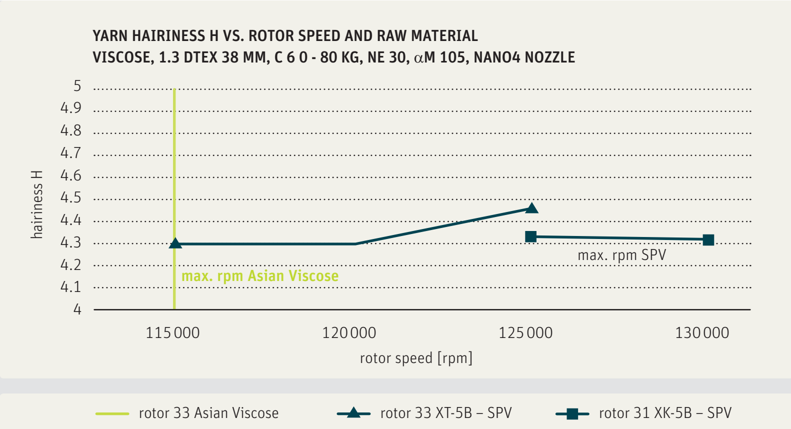

Fig. 24

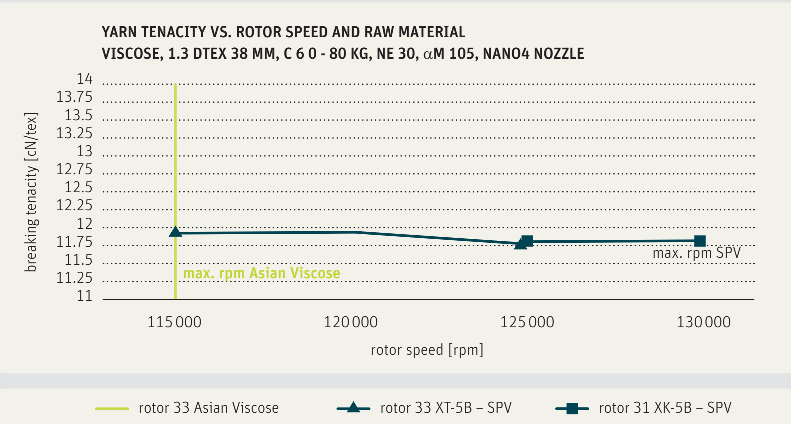

Fig. 25

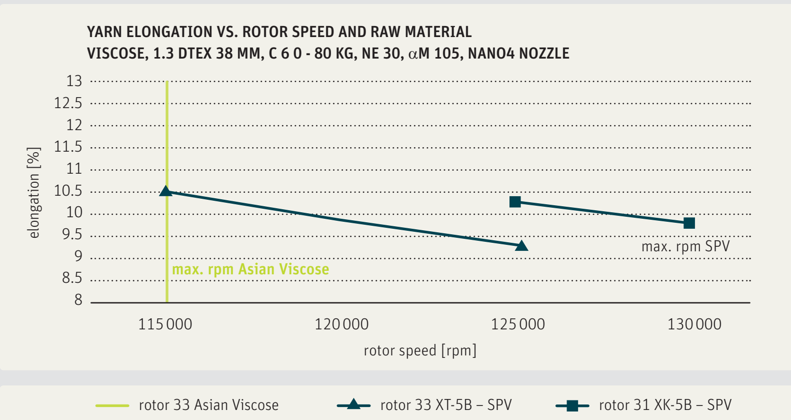

Fig. 26

The final question which has to be answered is the reason for the significant differences in the productivity of the rotor spinning machine with the different viscose types. Before this question is answered within the context of this study, yarn properties such as strength, elongation, hairiness and working capacity should first be considered in relation to rotor speed. As already evident from the fiber characteristics, the SPV viscose offers a higher fiber strength and elongation, a significantly lower percentage of short fibers and higher medium staple. Moreover, the fibers can be better integrated into the yarn, as it is reflected in a lower hairiness, a property that also has a positive effect on yarn strength and elongation (Fig. 24). Yarn strength and elongation decrease as a result of the yarn stress through the higher rotor speed and spinning tension. The loss of its elongation has a greater influence on this raw material than the loss of strength (Fig. 25 + 26). The mentioned properties therefore affect the working capacity of the yarn. It was interesting to see that the maximum rotor speed in each case occurred at the same working capacity of each viscose raw material (Fig. 27).

This shows that in order to handle the increasing tension with increasing rotor speed, the maximum rotor speed essentially depends on the working capacity of the fiber.

The limit prior to yarn break depends on the following additional raw material factors:
• fiber strength
• fiber elongation
• short fiber content or medium staple
• capacity of the fiber to integrate into the yarn,

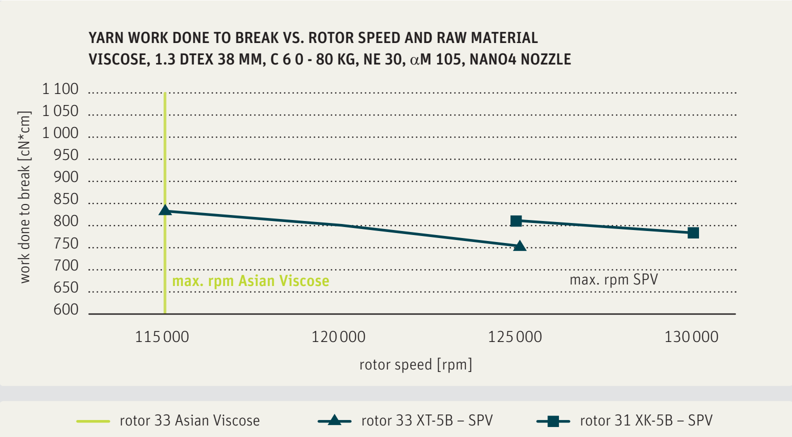

Fig. 27

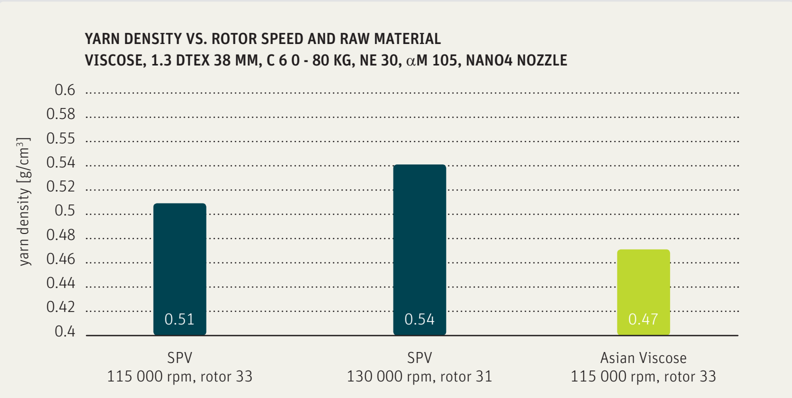

Fig. 28

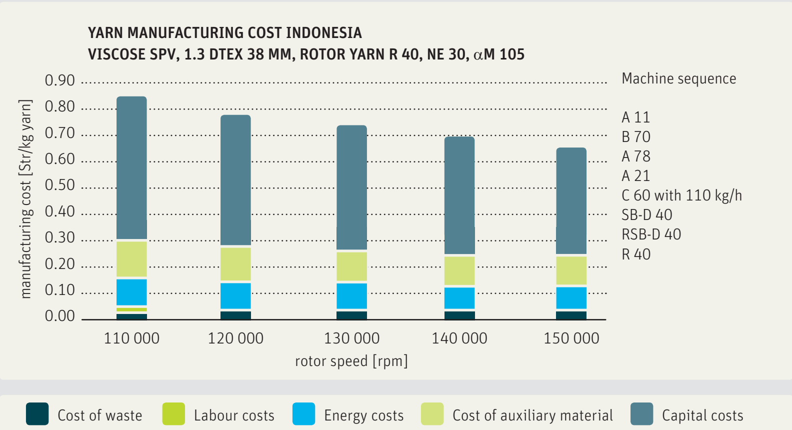

Fig. 29

but only when the general conditions such as:

- yarn fineness
- twist factor
- optimal nozzle for high speeds
- fiber fineness
- staple length,

are identical.

These factors could also be the reason for the differences in the maximum rotor speed between the two viscose types which we were able to see in this study. Apart from maximum rotor speeds, it should not be forgotten that a higher rotor speed equates to a worsening in yarn values. There are at least three main causes of this:

- The higher rotor speed leads to an increasingly different speed ratio between the opening roller outlet (VA) and rotor wall (VR).
- The increased fiber delivery rate per minute leads to greater disorientation in the fiber guide channel.
- The higher rotor speed leads to higher spinning tension and consequently greater friction on the yarn package and the elements involved in the spinning process.

Moreover, the yarn density increase with increasing rotor speed as a result of centrifugal force. Values such as yarn diameter and yarn density, given constant yarn fineness, affect the handling properties as well as the cover factor of the fabric (Fig. 28). The rotor speeds therefore not only affect the properties of the yarn and the textile fabric but also the production costs. The following example shows a reduction of approximately 20% in production costs between rotor speeds of 110 000 rpm and 150 000 rpm (Fig. 29).

SUMMARY

The combination of SPV viscose fibers and Rieter R 40 rotor technology, allows rotor speeds of 130 000 rpm resulting in a delivery speed of 175 m/min for yarns of Ne 30/1.

The optimal twist factor for SPV viscose processing is in the range α_m 100 - 110 (α_e 3.3 - 3.6). Based on the yarn properties which we have achieved a twist factor of α_m 105 (α_e 3.5) can be recommended for both knitting and weaving applications.

For the processing of SPV viscose on the R 40 rotor spinning machine, the nano4, MIMA 1 and MIMA 2 nozzles proved optimal in respect of rotor speed. The MIMA 1 and MIMA 2 nozzles were shown to be beneficial for achievement of the greatest yarn evenness.

Compared to a Viscose fiber commercially available on the Asian market, the use of SPV viscose fibers corresponds to an increase in productivity of approximately 13%, as a result of which the yarn production costs could be reduced by around 20%.

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2116-v2 en 1108 Printed in CZ

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