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DEVELOPMENTS IN TEXTILE TECHNOLOGY: ITMA 2003 REVIEW
PART II: SPINNING MACHINERY

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Abstract

This paper represents the second part of two papers in which I review some of the recent developments in staple fiber technology with emphasis on cotton and cotton/man-made blend systems. In this part, the focus is on spinning or yarn forming machinery. A great deal of the review will be based on machinery exhibited at ITMA 2003, in Birmingham, U.K. In addition, other developments that were not exhibited at ITMA will also be discussed.

Introduction

When one takes the responsibility of reviewing the new developments of short-staple spinning, the task in hand becomes extremely difficult because of the multi-facet issues involved in this interesting subject. Indeed, it becomes more of a philosophical issue rather than just a technological review. At ITMA 2003, major spinning machine players disappeared, Rieter, Zinser, and Suessen, despite their well known spinning developments. Under these circumstances, this paper should cease at this point. However, my addictive interest in this fascinating area prohibited me from doing so. This review is therefore a result of direct communications that I made with spinning machine makers before and after the exhibition which proved that the stream of development is continuous and innovations in spinning is more like a love affair to spinning machine developers.

From Conventional Ring to Modern Ring-Compact Spinning

The survival of ring-spinning from the 19th century until today despite the introduction of new spinning systems with higher speeds and shorter processes reflects a truly successful system and ingenious design. Such a resourceful system stands alone until today as the most flexible, most diverse, and most quality uncontested yarn forming system. It also stands as the most complex spinning geometry, which has stimulated researchers over the years attempting to resolve its complexity. Even more fascinating is the fact that the entire system is primarily controlled by a very small metallic element, the traveler, which is dragged at a speed of about 100 miles per hour over a metallic ring in a non-stoppable journey of over 30,000 miles, which can take from 10 to 15 days. This incredible status was a result of over fifty years of continuous development by spinning machine makers.

Despite the development status of today's ring spinning, more development is in progress. Indeed, the system faces three basic limiting factors [El Mogahzy and Chewning, 2002]:

1. The complex interrelationships between different spinning parameters, leading to an inevitable linkage between twisting and winding. This limitation has not been resolved yet and it has resulted in the development of new spinning technologies.
2. The ring/traveler system with its associated high friction heat leading to traveler wear out and deterioration of yarn quality over the traveler lifetime. This factor leads to a limiting traveler speed and low spinning production. In recent years, Rieter introduced the Orbit system in which a different geometry of traveler/ring system was introduced to allow greater area of traveler/ring contact over which friction heat can dissipate. More recently, El Mogahzy and Hady [NTC-2003] developed a new traveler-less system using a magnetic ring. This system resulted in rotational speeds approaching 60,000 rpm and it is still under development.
3. The third limiting factor is fiber divergence during spinning, which results in fiber loss, fly generation, and high hairiness. This limiting factor was overcome through the development of compact ring spinning.

In recent years, the introduction of ring-compact system was a refreshing shift in the direction of ring spinning development targeted toward quality levels that are even higher than those established by the conventional system. Compact or condensed spinning is a new concept of yarn forming. It represents a fundamental modification of the conventional ring-spinning system that aims at producing a better surface integrity of spun yarns and maximizing the fiber contribution to yarn strength. The idea stems from the necessity of controlling the dimensions of the spinning triangle to improve yarn strength and reduce yarn hairiness.

Compact spinning was first introduced at ITMA 99 in Paris. At ITMA 2003, the key pioneers of Compact spinning (Rieter, Suessen, and Zinser) did not show up. Due to the increasing interest in this new spinning, I will attempt to briefly review its principle and some of the merits associated with it since its introduction.

Principle of Compact Spinning

In simple practical terms, it is well known that one of the features of the conventional ring spinning is that the width of the fiber strand undergoes dynamic changes as fibers flow from the drafting zone to the twisting zone (see Figure 1). In the drafting system, the width of the fiber strand ($W_{F\text{-}Ring}$) is large. As the fibers emerge from the nip of the front drafting rollers, the fibers form a triangular shape, which is commonly known as the spinning triangle. The height of this triangle is the distance from the nip of the front roller to the twisting point (the onset of the yarn formation). As the fibers form a spinning triangle, they tend to condense widthwise. Since fibers are different in their dimensional characteristics (length, fineness, crimp, and surface integrity), the formation of the spinning triangle does not occur without a loss of some fibers and divergence of other fibers from the main stream of the triangular shape (fibers a, b, c, d in Figure 1). In addition, the spinning triangle depends mainly on spinning tension, and is inversely proportional to it. As a result, the width of the spinning triangle ($W_{T\text{-}Ring}$) is always smaller than the fiber strand width in the drafting system ($W_{F\text{-}Ring}$). The divergence of fibers from the mainstream results in preventing those fibers from being fully incorporated in the yarn structure. Those fibers will not fully share the loading of yarn under tensile stresses, leading to a loss in yarn strength. Furthermore, they are likely to form long protruding hairs (hairiness) that can be stimulated further by the ring/traveler system. Other possibilities include fly generation and fiber wrapping around the already twisted yarn in a disorderly arrangement.

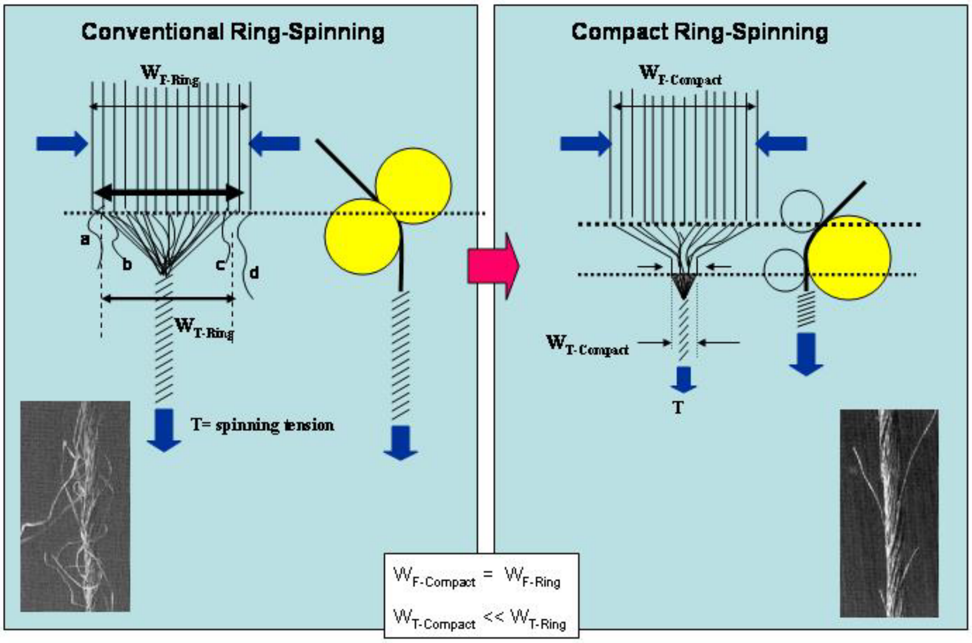


Figure 1. Comparison between Fiber Compactness in Conventional Ring-Spinning and Compact Ring-Spinning [El Mogahzy and Chewning, 2002].

The spinning triangle is obviously a non-static formation; millions of triangles are being formed during yarn formation as new fibers are delivered from the nip of the front roller and form new triangles every moment. Prior to twisting, the fibers in the outer layer of the triangle exhibit higher tension than those in central area of the triangle. As soon as the fibers are released from the nip of the front roller, a momentary (unnoticeable) collapse of the fiber arrangement in the triangle takes place as the highly tensioned outer fibers seek release by migrating toward the center of the triangle deviating those that were in he center to the outside. This critical phenomenon is called “fiber migration” and it is a result of the tension differential within the fibers in the triangle. Fiber migration contributes a great deal to the strength of ring-spun yarn by providing cross-linking between fibers. Finally, as the fibers enter the twisting point, the width of the strand is reduced further to the thickness of the yarn being formed.

In light of the above introduction, it is clear that the formation of the spinning triangle has its merits and also has its flaws. The merits stem from the opportunity to allow the fibers to intermingle by the migration mechanism, which improves fiber cohesion. However, the obvious flaw is the propensity to divergence by some fibers as a result of the change in the width of fiber flow. Accordingly, traditional approaches to reduce fiber divergence or to minimize the difference between the width of the fiber flow, $W_{F\text{-}Ring}$, in the drafting system and the width of the spinning triangle, $W_{T\text{-}Ring}$, aimed at keeping the integrity of the spinning triangle to obtain its obvious benefits, meanwhile reduce the width difference through a number of ways including [Stalder, 1995, El Mogahzy & Chewning, 2002]:

- Condensing the fiber flow at the nip of the front roll by increasing the twist in the roving to an optimum level that will allow better compactness of the fibers during the drafting process (that is keeping the fibers sideways together). This method suggests that the roving twist can act as a fiber condenser mainly in the break-draft zone, and partially at the main draft zone.
- Using mechanical approaches such as utilizing a funnel shaped condenser, located between the aprons and the delivery cylinders. Such an element can in fact add a condensation effect to the fiber flow. The only disadvantage is that due to the rubbing action between the funnel and the fibers the drafting action is disrupted leading to deterioration in yarn evenness, and increase in imperfections.
- Optimizing twist/draft combination
- Using highly uniform roving through appropriate drawing and good fiber blending
- Using aerodynamic condensation after the drafting zone, but before the yarn formation
- Using front roller of special shape that allows confinement of fibers as they merge from the nip of the front roller (this approach is currently used in two long-staple fiber spinning machines, namely: Com4Wool by Cognetex and FP03 by Officine Gaudino)
- Using magnet compacting. LMW used this approach in its short-staple compact spinning system called “LR6AX” at ITMA 2003

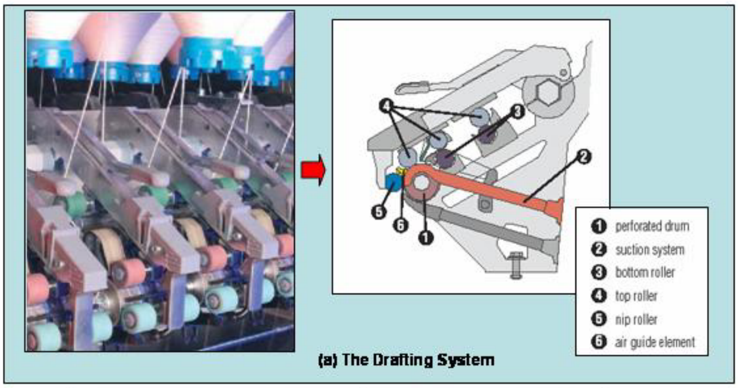
Most commercial systems available in the market today operate on the principle of using a condensing mechanism (typical aerodynamic condensation) at the exit zone of the drafting system.

Rieter “ComforSpin”K44

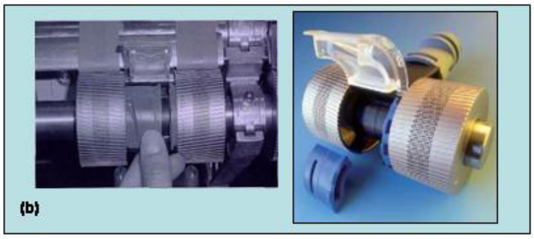
The compact spinning concept illustrated in Figure 1 is the one represented by the Rieter "ComforSpin" process. In this system, aerodynamic forces are used to laterally condense the drafted fiber sliver after the main drafting zone. As a result, the spinning triangle becomes so small that it is almost eliminated.

As shown in Figure 2.a, the Rieter K44 ComforSpin machine consists of a 3-roller, double-apron drafting system. The exit zone of this system is modified to allow fiber condensation; the exit roller is replaced by a perforated drum, (1), within which is a stationary suction unit that is connected to the machine's central extraction unit (2). The fibers delivered by the exit nip line of the drafting system are held on the surface of the perforated drum, moving at the drum's peripheral speed. Thus, the ComforSpin® technology allows aerodynamic parallelization and condensation of the fibers after the main draft. The spinning triangle is thus reduced to a minimum. Obviously, the heart of the K 44 ComforSpin® machine is the compacting zone, which consists of the perforated drum, suction insert, and air guide element.

The positively driven perforated drum is hard-wearing and resistant to fiber clinging. Inside each drum is an exchangeable stationary suction insert with a specially shaped slot (Figure 2.b). This is connected to the machine’s suction system. The air current created by the vacuum generated in the perforated drum condenses the fibers after the main draft. The fibers are fully controlled all the way from the nipping line after the drafting zone to the spinning triangle. An additional nip roller (5, Figure 2.a) prevents the twist from being propagated into the condensing zone. The compacting efficiency in the condensing zone is enhanced by a specially designed and patented air guide element (6). Optimal interaction of the compacting elements ensures complete condensation of all fibers. This results in unique COM4® yarn characteristics.



(a) The Drafting System



(b)

Figure 2. Features of Rieter COM4® K44 System.

The basis for the K 44 is the familiar Rieter Ring-Spinning machine G 33 with many of its features including:

- SERVOgrip – doffing without under-winding
- FLEXIdraft – adjustment of the main draft and yarn twist at the push of a button
- INTERcool integrated cooling system –savings on air-conditioning costs
- Separate, bilateral drafting system drive –stable long-term yarn quality
- ROBOdoff – reliable doffing with doffing time of 1min 50 sec
- SERVOdisc – maintenance-free cop/tube transport
- ROBOload – flexible cop/tube handling

As can be seen in the microscope pictures of yarn structure (Figure 1) compact yarn is uniquely distinguished from the conventional ring-spun yarn by lower hairiness and improved surface integrity. This is a direct result of the compacting effect of K44. During yarn formation all fibers are condensed and gathered parallel to each other in the compacting zone. This results in better contribution and utilization of fibers in the yarn structure. Indeed, this largely explains the higher strength of compact yarn in comparison of conventional ring-spun yarn of the same material, count, and twist. Studies conducted by Rieter indicate the following merits of the COM4® yarn:

- Higher fiber utilization
- Higher tenacity with same twist factor, or same tenacity with reduced twist factor
- Lowest hairiness (highest reduction in hairs longer than 3 mm)
- Better coefficient of variation (CVm)
- Fewer weak points
- Better imperfections (IPI)
- Higher abrasion resistance

Results of some of the tests conducted by Rieter in actual spinning mills using COM4® are shown in Figure 3.

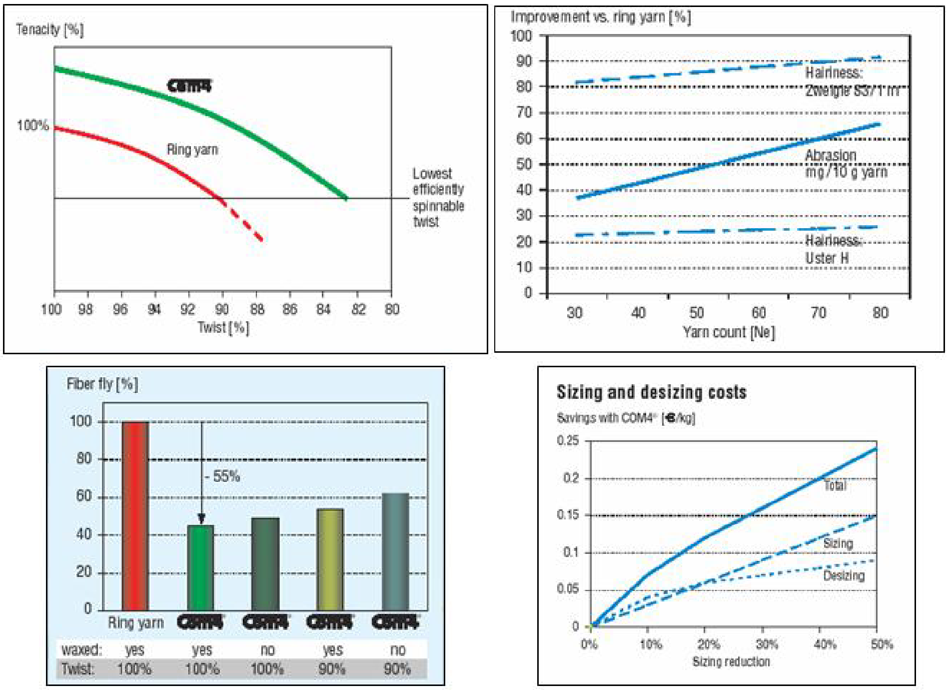
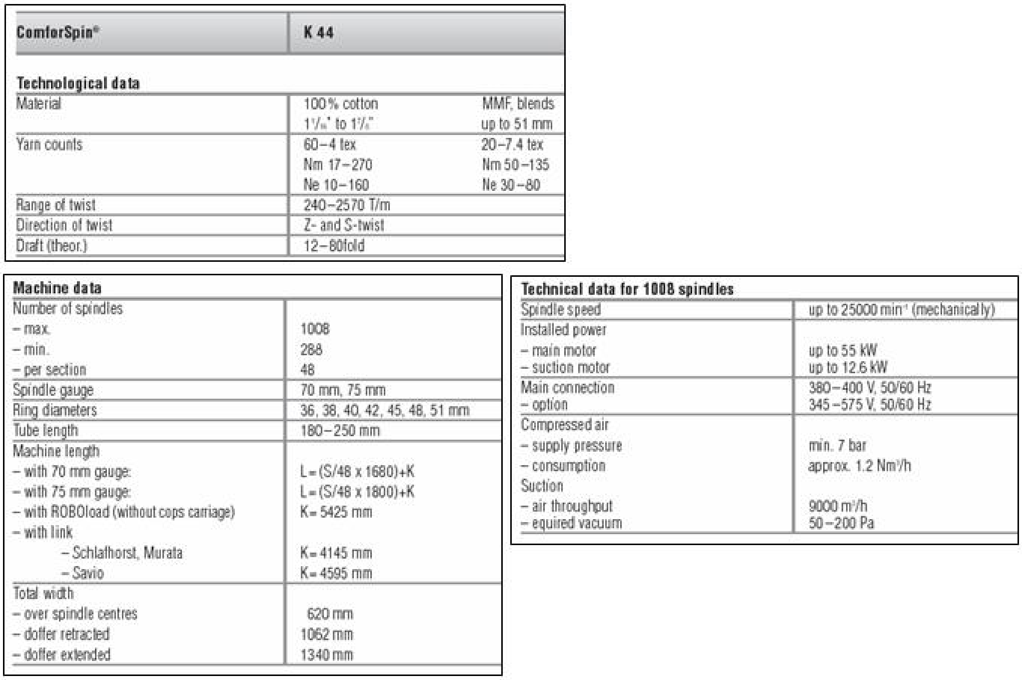


Figure 3. Features of Rieter COM4® K44 System.

Some of the technical data associated with COM4® K44 are shown in Figure 4.



ComforSpin®	K 44	
Technological data		
Material	100% cotton $1\frac{1}{16}$" to $1\frac{7}{8}$"	MMF, blends up to 51 mm
Yarn counts	60–4 tex Nm 17–270 Ne 10–160	20–7.4 tex Nm 50–135 Ne 30–80
Range of twist	240–2570 T/m	
Direction of twist	Z- and S-twist	
Draft (theor.)	12–80fold	

Machine data	
Number of spindles	
– max.	1008
– min.	288
– per section	48
Spindle gauge	70 mm, 75 mm
Ring diameters	36, 38, 40, 42, 45, 48, 51 mm
Tube length	180–250 mm
Machine length	
– with 70 mm gauge:	L=(S/48 x 1680)+K
– with 75 mm gauge:	L=(S/48 x 1800)+K
– with ROBOload (without cops carriage)	K=5425 mm
– with link	
– Schlafhorst, Murata	K=4145 mm
– Savio	K=4595 mm
Total width	
– over spindle centres	620 mm
– doffer retracted	1062 mm
– doffer extended	1340 mm

Technical data for 1008 spindles	
Spindle speed	up to 25000 min⁻¹ (mechanically)
Installed power	
– main motor	up to 55 kW
– suction motor	up to 12.6 kW
Main connection	380–400 V, 50/60 Hz
– option	345–575 V, 50/60 Hz
Compressed air	
– supply pressure	min. 7 bar
– consumption	approx. 1.2 Nm³/h
Suction	
– air throughput	9000 m³/h
– equired vacuum	50–200 Pa

Figure 4. Technical Data of Rieter COM4® K44 System.

<u>Suessen EliTe® System</u>

Suessen introduced its EliTe®Compact spinning in ITMA 99, Paris. Since then it has sold more than 650,000 EliTe®Compact Spindles. The Suessen EliTe®Compact spinning system is available as modernization packages, called EliTe®CompactSet-S for existing ring spinning frames in short staple spinning and EliTe®CompactSet-L for existing ring spinning frames in long staple spinning. The EliTe®CompactSet is available for almost every kind of machine type made by Rieter, Lakshmi, Shanghai, Jingwei, Zinser, Toyota and many other manufacturers.

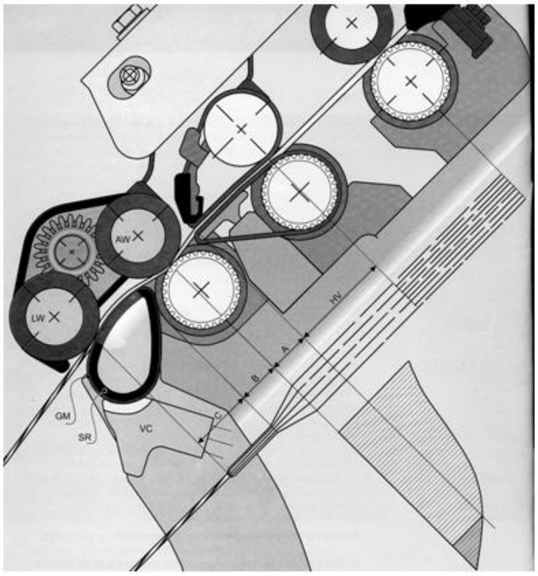
In principle, the SUESSEN EliTe Spinning System operates in such ways that after the fibers leave the drafting system they are condensed by an air-permeable lattice apron, which slides over an inclined suction slot. The fibers follow the outer edge of this suction slot and at the same time they perform a lateral rolling motion. Above the front bottom roller of the drafting system, the fiber band influenced by high draft is spreading. In the area of the suction slot, which is covered by the lattice apron (see Figure 5), the fiber band is condensed. Commencing from the semi-dotted clamping line of the EliTe Q Top Roller, twist is being inserted. As a result, the yarn twist flows right up to the clamping line leading to a more round and smooth strand without a spinning triangle.

Figure 6 provides more details on the EliTe®Compact system. The system consists of a tubular profile subjected to negative pressure and closely embraced by a lattice apron. The delivery top roller, fitted with rubber cots, presses the lattice apron against the hollow profile and drives the apron, at the same time forming the delivery nipping line. The tubular profile has a small slot in the direction of the fiber flow, which commences at the immediate vicinity of the front roller nipping line and ends in the region of the delivery nipping line. This creates an air current through the lattice apron via the slot towards the inside of the profile tube. The air current seizes the fibers after they leave the front roller nipping line and condenses the fiber strand, which is conveyed by the lattice apron over a curved path and transported to the delivery nipping line. As the slot, being under negative pressure, reaches right up to the delivery nipping line, the fiber assembly remains totally compacted. This results in a substantial disappearance of the spinning triangle.

The suction slot can be arranged at an angle to the direction of fiber flow, especially when processing short fibers. This ensures that the fiber ends, during their transport from the front roller to the delivery nipping line, are well bound into the strand. It also creates a cross-directional force during the fiber transport, which in turn causes the fiber assembly to rotate around its own axis so that the fiber ends are closely embedded into the fiber assembly.

Both Rieter COM4® K44 System and EliTe® Compact System are claimed to offer many advantages including:

- Better fiber utilization than conventional ring spinning.
- Due to better fiber utilization including short fibers in compact yarn, about 6%fewer combing noils are possible.
- It is often possible to replace classical two-ply yarns by single EliTe®Yarns or conventional combed yarns by carded EliTe®Yarns.
- Lowest hairiness (highest reduction in hairs longer than 3 mm). Accordingly, sizing can be completely or partially dispensed with (up to 50% reduction). The same can be said about singeing (up to 7% fibers can be saved).
- If the strength of the conventional yarn is sufficient for the intended application, using the EliTe® technology will allow a reduction of twist by approximately 20 % (particularly for knit yarns). This means a softer yarn, increased production and reduced energy consumption.
- The ends-down rate in spinning is claimed to be reduced by 30 to 60%.
- Applying the same winding speed as with conventional ring yarns, there are less raised points in these yarns and the increase in yarn imperfections is reduced because they have a better resistance to shifting. Higher winding speeds are therefore possible with compact yarns.
- Owing to the lower hairiness and higher tenacity of compact yarns, the ends-down rate in beaming is reduced by up to 30%. This leads to higher beamer efficiency, higher production and fewer personnel for repair of ends-down in beaming.
- In weaving, merits reported included: fewer ends down, higher productivity, reduced cleaning frequency.
- In knitting, the use of compact yarns is claimed to increase yarn strength and reduce formation of fluff. In addition, the low hairiness of compact yarns often permits to dispense with usual waxing. In addition, it is claimed that fiber or yarn abrasion is to be reduced by 40% due to low hairiness. Low pilling values are also claimed.
- Fabric handle becomes softer, print definition more brilliant due to better dye uptake, pilling resistance, luster and strength increase.
- In finishing, greater brilliance of color, intensive dye penetration, and no singeing before printing were reported.



[c – the curvature, LW = deliver roll, GM = lattice apron, SR = suction tube]

Figure 5. Suessen EliTe® Spinning System.

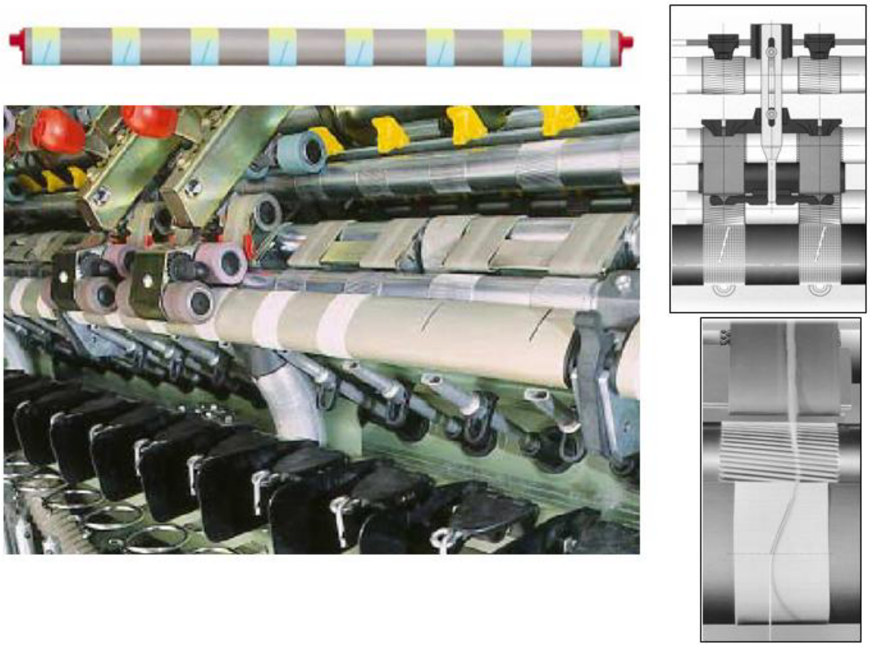


Figure 6. Suessen EliTe® Spinning System.

Compact spinning being a relatively new system requires special handling of its operational procedures. In this regard, the makers of EliTe® Compact System make the following recommendations:

- **EliTe spinning machines must be separated from conventional spinning machines**. EliTe Spinning Machines have a considerable airflow rate. For example, a machine with 1008 spindles sucks in about 60 cubic meter of air per minute (i.e. it has the effect of a vacuum cleaner). The ambient air is sucked into machine and most of the fly and dirt contained in it is deposited on the EliTe Machine. Although EliTe Spinning Machines generate considerably less fly than standard ring spinning machines, they are soon covered with dust and fly if they are installed in the same room as conventional spinning machines. The fly has a negative effect on the yarn in the condensing zone and the smooth running of the lattice apron.

- **Suitable humidity and maximum room temperature is 33 C.** The fibers in the condensing zone are exposed to the room conditions without any protection. If the air humidity is too high, there will be a higher tendency towards roller laps. If the air is too dry, more fly will be generated. If the room temperature is too high, there will be higher friction values and premature wear.
- **The front top roller should be precisely 3.5 mm offset towards the operator in relation to the front bottom roller of the drafting system**. This is to ensure that the top edge of the suction slot in the EliTe machine is precisely set at the nip line of the delivery top roller. If the nip line cuts the slot, condensation is impaired. The hairiness of the yarn increases and the tearing strength is reduced. If the nip line is behind the slot, part of the spinning torsion may get into the condensation zone, resulting in an increased ends-down rate and damaged lattice aprons.
- **Precision of traverse mechanism**. The roving must run over the slot in such a way that from the operator's view, the fibers move from the top right to the bottom left. If the fibers run over the slot top from the L.H. side, they make an S-shaped movement causing certain unsteadiness in the condensing zone. This has a negative effect on yarn quality values.
- **Lattice aprons and EliTe tubes must be cleaned from time to time**. EliTe tubes and lattice aprons are the most important components of the condensing system. In the center area, where the suction is active, a permanent airflow keeps the lattice aprons clean. To the left and right of this area, the lattice apron can be clogged by fine dust. With the time, this results in a considerable increase of the friction between the lattice aprons and the EliTe tube. If this friction is too high, erratic running of the lattice apron can occur. Therefore, lattice aprons and tubes should be removed from the machine from time to time and cleaned.
- **Optimum running speed.** In the case of EliTe spinning machines, return on investment is not based on higher production, but on the production of yarn of supreme quality. In other words, it is not the ultimate increase in speed, but the level of yarn quality that is important.

As mentioned earlier, the Elite system can be installed on existing ring spinning system. Suessen has developed modernization packages for current types of existing ring frames. Apart from components for technological upgrading they include the elements that are inevitable to be replaced in a conventional ring frame. A typical modernization package will include the following components:

- Top weighting arm
- Front bottom roller
- Reinforcement of draft gearing
- EliTe Components for the drafting system with relevant brackets
- Elian suction unit

Compared with an investment in new ring frames, the modernization of the drafting system of an existing machine is more attractive considering the capital expenditure. As the familiar basic machine is maintained after modernization, the organization of the mill is not affected. Production loss during the period of erection is within an acceptable range.

Some of the yarn results comparing Elite compact yarns with conventional ring yarns (published by Suessen) are shown in Figures 7 through 9. The differences in fabric appearances for knit and woven fabrics are shown in Figures 10 and 11, respectively. As can be seen in these figures, all evaluations yielded favorable results for compact yarns.

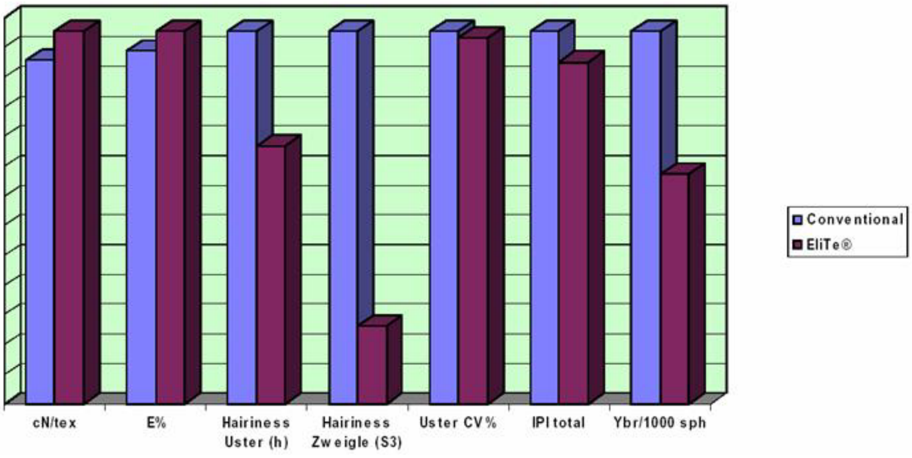


Figure 7. Elite Yarn vs. Conventional Ring Yarn for 100% Carded Cotton, Ne = 9.5, TM = 3.8 [Thomas Wiget, 2000].

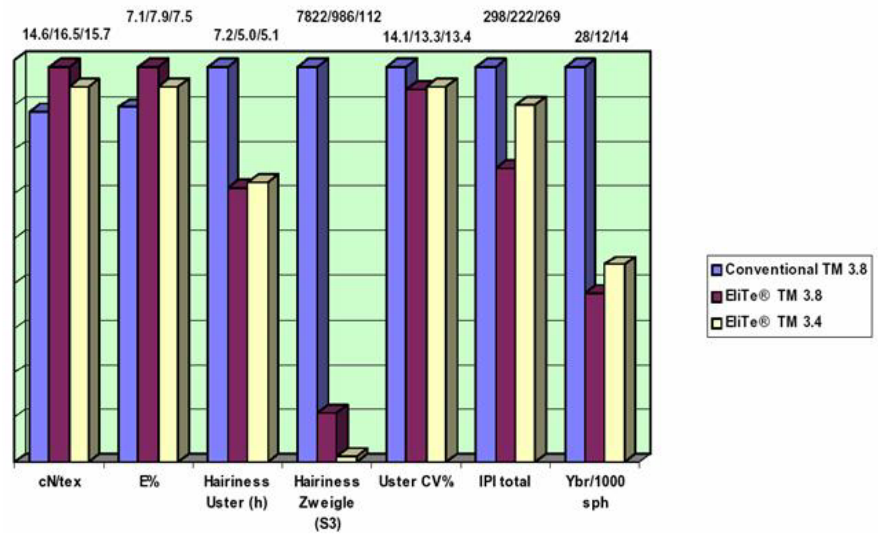


Figure 8. Elite Yarn vs. Conventional Ring Yarn for 100% Carded Cotton, Ne = 18, TM = 3.8/3.8/3.4 [Thomas Wiget, 2000].

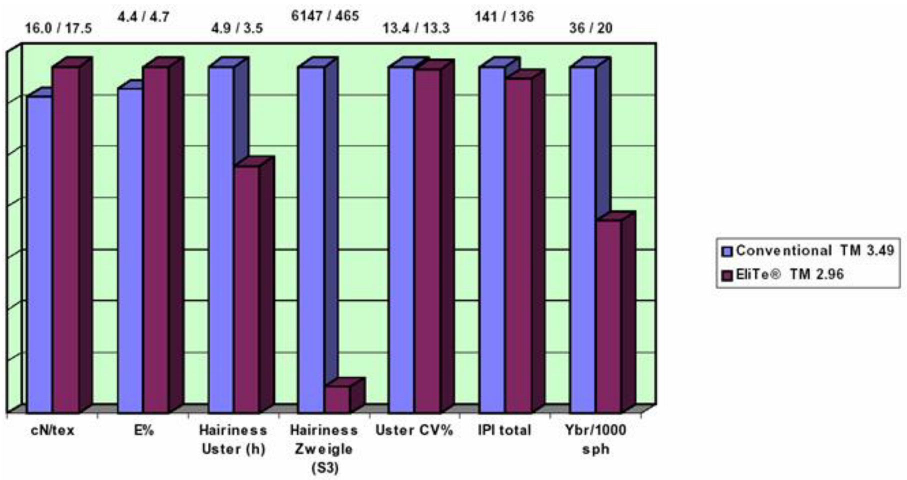


Figure 9. Elite Yarn vs. Conventional Ring Yarn for 100 % Combed Cotton, Ne = 60, TM = 3.49-2.96 [Thomas Wiget, 2000].

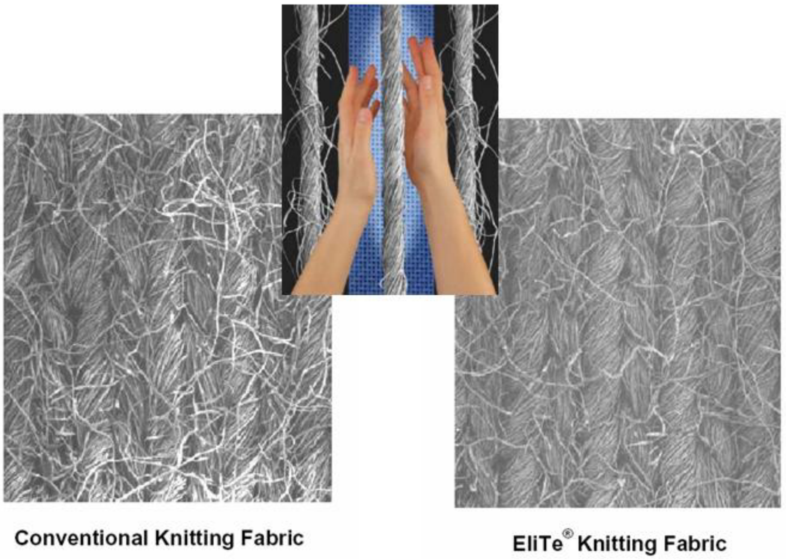


Figure 10. Elite vs. Conventional Ring Knit Fabric [Thomas Wiget, 2000].

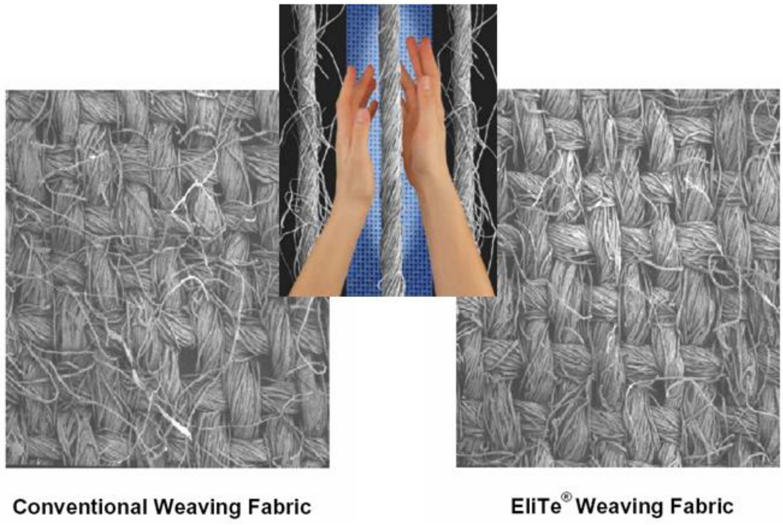


Figure 11. Elite vs. Conventional Ring Woven Fabric [Thomas Wiget, 2000].

Compact or Condensed Twist Systems

In addition to the EliTe Compact system discussed above, Suessen also introduced new innovations in 2003 at ShanghaiTex 2003 show. These include:

- **EliTwist®** production of two-ply yarns directly on the ring-spinning machine with compact spinning technology.
- **EliCore®** Core-Yarn device for EliTe®CompactSet
- **EliCoreTwist®** production of two-ply yarns with Core-Yarn directly on the ring spinning machine with compact spinning technology

These three systems stems essentially from the principle of compact spinning. Indeed, one may collectively place these systems under the category of "Compact Twist" system. They are all based on the concept of twisting in a condensing zone to minimize fiber divergence and twist loss. In other words, the principle of eliminating the spinning triangle by incorporating a condensing zone after the drafting system represents the key feature of these systems. One of the main reasons that encouraged Suessen to move into developing systems for special purpose yarns was to expand the capabilities of the Elite Compact system from its original market niche of combed yarn for woven fabrics to other fabric types involving ply yarns and core yarns.

Efforts to spin two-ply yarn directly on the ring spinning frame have been based on drafting two fiber strands in parallel at a relatively large distance. The two fiber strands are then combined immediately after passing the nip of the front rollers of the drafting system at a twisting point (Figure 12.a) where they both are twisted at the same direction. They are then plied at the same twist direction. In this case, the ply twist is larger than the single strand twist, which is equal in both strands. The amount of twist (tpi) generated in the two yarn legs up to the nip point is about 20% lower than the twist of the ply yarn after the twisting point. In other words, the twist coefficient of the two yarn legs is only about half as high as in the final two-ply yarn. Systems operating based on this principle include the familiar SIRO-SPUN and DUOSPUN systems. As shown in figure 12.a, the twist propagates upward through the two fiber strands and each fiber strand forms a long spinning triangle at the nip of the front roller. The dimensions of the twist triangle (height and width) typically depend on the distance, h, between the twisting point Z and the nip point of the front roller pair, and the distance, A, between the two emerging fiber strands. Typically, the closer the point Z to the nip point (smaller h), the lower the spinning tension and the smaller the distance, "A," between the two fibrous strands (Brunk, 2003).

Since the system is basically a conventional ring spinning, it has the same problems associated with the spinning triangle discussed earlier. These include fiber loss at the drafting system exit, particularly here due to the very low twist in the two yarn legs. Therefore, commercial systems of this type typically operate at slow speeds.

The patented EliTwist process allows reducing the twisting triangle to a degree that the restrictions mentioned above are eliminated. This is realized by having the two fiber strands first pass a condensing zone. During condensing, both components get closer and reach a minimum distance by means of two suction slots in the condensing zone in a V-shaped arrangement (see Figure 12.b). As a result, the two strands, after leaving the condensing zone, do not form spinning triangles. Consequently, no fibers are sticking out, spreading up to the other yarn component or not being embedded in the yarn. The twist, running into the two yarn legs from the twisting point, need not overcome any resistance and easily reaches the clamping line. As a result, the two fiber strands can be led very closely and the twisting point has a very small distance from the nip of the front roller pair. In short-staple spinning, this distance is only between 4 and 5 mm, depending on the spinning tension. One obvious merit of this system in comparison with the SIRO system (per Suessen claim) is the substantial reduction in fly generation in the EliTwist system. According to Suessen, yarn surface and appearance of EliTwist are comparable to a single compact yarn. However, as the twist in the two yarn legs is identical, EliTwist has more snarling tendency. Another advantage of EliTwist over all conventional spin-twisting methods is that no detection devices are required for the twisting triangle. In case of a short-term material interruption at one of the two components, the broken component will piece up automatically due to the prevailing geometrical conditions.

The concept of EliTwist is expanded to allow making core yarns by feeding a filament in the center of the twisting triangle, i.e. directly at the twisting point as shown in Figure 12.b. This is achieved by means of the special SUESSEN Core Yarn Device EliCore and it allows complete covering of the yarn core (Brunk, 2003). It is also possible to feed additional threads parallel to one or both yarn legs.

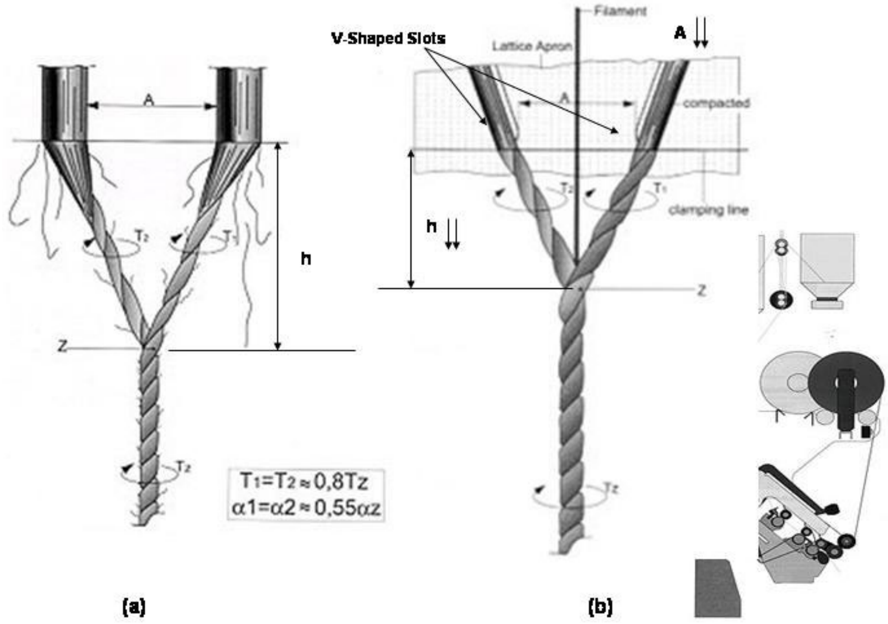


Figure 12. The Principle of Compact Twist System [Norbert Brunk, 2003].

Zinser AIR-COM-TEX 700® System

The Zinser AIR-COM-TEX 700® system was introduced in ITMA 99 Paris. It also works on the basis of eliminating the spinning triangle. This system uses a conventional 3-cylinder drafting system. The fibers emerging from this drafting system are taken by airflow, and condensed under suction on a perforated belt surface (see Figure 13). The condensed fiber strand thus undergoes a substantial reduction in width prior to twisting. This, in turn, reduces the difference between the width of the fibers emerging from the drafting system and the yarn diameter (i.e. total elimination of the spinning triangle).

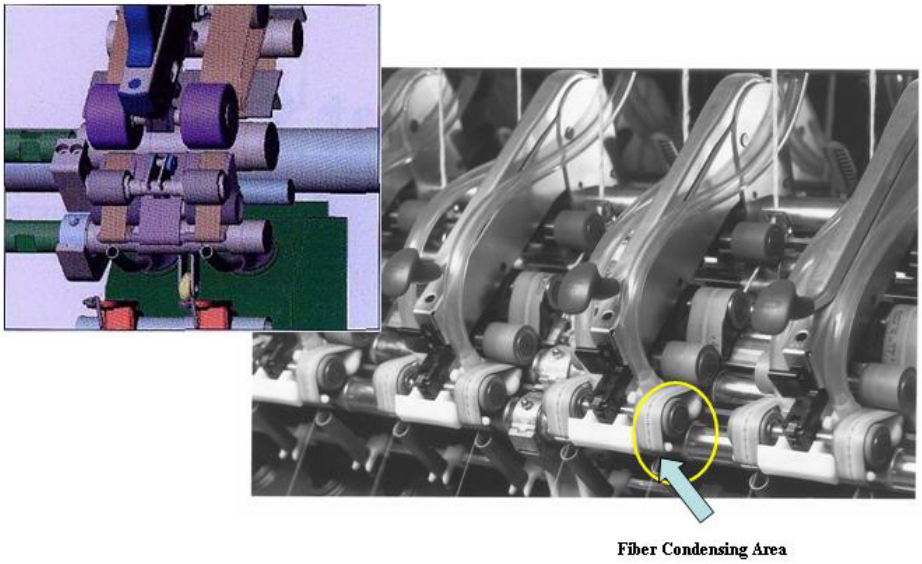


Figure 13. Zinser AIR-COM-TEX 700® condenser Ring Spinning.

RoCoS Rotorcraft Compact Spinning

The only compact system of short staple fiber yarns exhibited at ITMA 2003 was the RoCoS Rotorcraft Compact system [LR6AX machine by LMW]. Although it has not been fully tested, this system uses a unique compacting element that is different than the systems discussed above. On the economical basis that other aerodynamic condensing systems are not energy efficient and require a great deal of maintenance effort, RoCoS, Rotorcraft Compact Spinning System works without air suction and uses magnetic-mechanical principles only. As shown in Figure 14, the bottom roller 1 supports the front roller 2 and delivery roller 3. The condensing zone extends from clamping line A to clamping line B. A precise magnetic compactor 4 is pressed by permanent magnets without clearance against cylinder 1. It forms together with the bottom roller an overall enclosed compression chamber whose bottom contour, the generated surface of cylinder 1, moves synchronously with the strand of fibers and transports this safely through the compactor. Accordingly, compact yarn is produced by condensing the fiber strand in a magnetic condensing zone, arranged after the drafting system, to such a degree so as not to allow the formation of a spinning triangle while twisting the strand of fibers into yarn. The system is claimed to reduce yarn hairiness and improve yarn strength. It is also claimed to be suitable for cotton, pure and as blends with synthetic fibers, as well as for pure synthetics with a maximum staple length of 60 mm (2.5"). It is also claimed to be suitable for wool, pure and as blends with synthetic fibers as well as for pure synthetics, having a minimum staple length of 50 mm (2"). With regard to yarn counts and twist, the standards usual in the industry are applicable. However, compactors for coarse, medium and fine count yarns are used to guarantee ideal compacting.

The design of the RoCoS system makes it equally suitable for application in new machinery as well as for retrospect introduction in existing machines. The conversion of a standard ring spinning frame to RoCoS can be undertaken by the mill maintenance personnel without any problems.

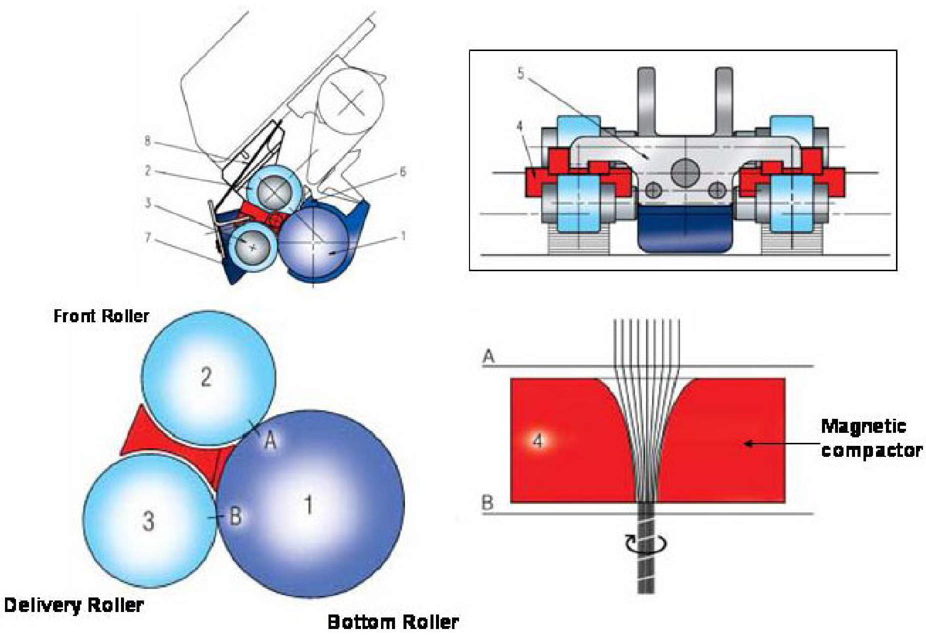


Figure 14. RoCoS Rotorcraft Compact Spinning.

Toyota Compact Spinning

Japan-based Toyota Industries Corp. will also begin production of the RX240NEW-EST, which combines the company's RX240NEW spinning frame with its new compact spinning system. Toyota reports the system exceeds conventional ring-spinning capabilities and produces yarns of exceptionally high quality. Its condensing device consists of a suction slit and a perforated apron, providing smooth collection of fleece fibers. Elimination of the spinning triangle at the delivery section of the front roller enables spinning of even yarn with low hairiness.

Developments in Air-Jet Spinning

The conventional air-jet spinning (Figure 15) uses the principle of false-twisting to produce a yarn of uniquely different structure from that of ring spun yarn. While ring spinning is characterized by continuity in the fiber flow to produce a fully twisted yarn, air-jet spinning requires a separation of some fibers to form a sheath, which wraps around a core of falsely twisted parallel fibers. The input strand in air-jet spinning is a drawn sliver, which may be carded or combed. Drafting is achieved using multiple zone roller drafting. The consolidation mechanism in air-jet spinning is achieved by blowing out compressed air through air nozzle holes of about 0.4mm diameter to form an air vortex. The air revolves at high speed (more than 3 million rpm). Thus, the rotating element in air-jet spinning is air. This results in a rotation of the fiber bundle at a rate typically ranging from 200,000 to 300,000 rpm. This high rotational speed allows high deliver speed of up to 300 m/min.

The first Murata model of air-jet spinning was introduced in 1979. In this model, two air nozzles were used to produce a fasciated yarn. The first nozzle creates an "end-opening" action and the second nozzle provides a false twisting action. To simplify the principle of the consolidation mechanism, suppose that only nozzle 2 is at work and that air is rotating in a clockwise direction. This action will result in twisting the fibers fed to the nozzle to form a yarn. When the yarn leaves the nozzle, untwisting takes place. Thus, with one air nozzle, a case of pure false twisting is achieved. In the actual machine, the first nozzle is positioned between the nip of the front roller and the second nozzle, with air rotating in a counterclockwise direction. Thus, the two nozzles apply air rotation in two opposite directions. However, the air in the second nozzle has a higher rotational speed than the first nozzle to avoid complete false twisting.

The fiber strand, coming out of the delivery roll, forms a spinning triangle similar to that in ring spinning. However, fibers in this triangle are under much less tension than those in ring spinning. In other words, the fibers in the triangle are comparatively loose. The air rotation of the fiber strand in the two nozzles results in ballooning the fiber bundle between the front roller and nozzle 1, and in turning the balloon in nozzle 2. This balloon has no significant tension, which results in some fibers being raised from the bundle surface and move freely. This process is called "the end-opening" action. Thus, the opposite rotation of air in nozzle 1 assists in detaching some fibers from the input strand. Accordingly, the consolidation mechanism results in two actions: false twist action and end opening action. The idea is to transmit the twist inserted by air rotation in nozzle 2 to the fibers at the nip of the front roller, and to detach some fibers from the twisted strand by the rotation of air in nozzle 1 in opposite direction. This end opening action takes place at the moment the twist in the second nozzle is imparted. As the strand passes through the second nozzle, it will consist of detached fibers (outer layer) and twisted fibers (the core). When the fiber strand exits the second nozzle, the twisted core will immediately tend to untwist and the detached fibers will wrap around the core fibers. This results in a yarn consisting of a core of parallel fibers, wrapped at some points along its length with fiber wrappers. Thus, the primary source of strength of air-jet spun yarn results from effective fiber wrapping.

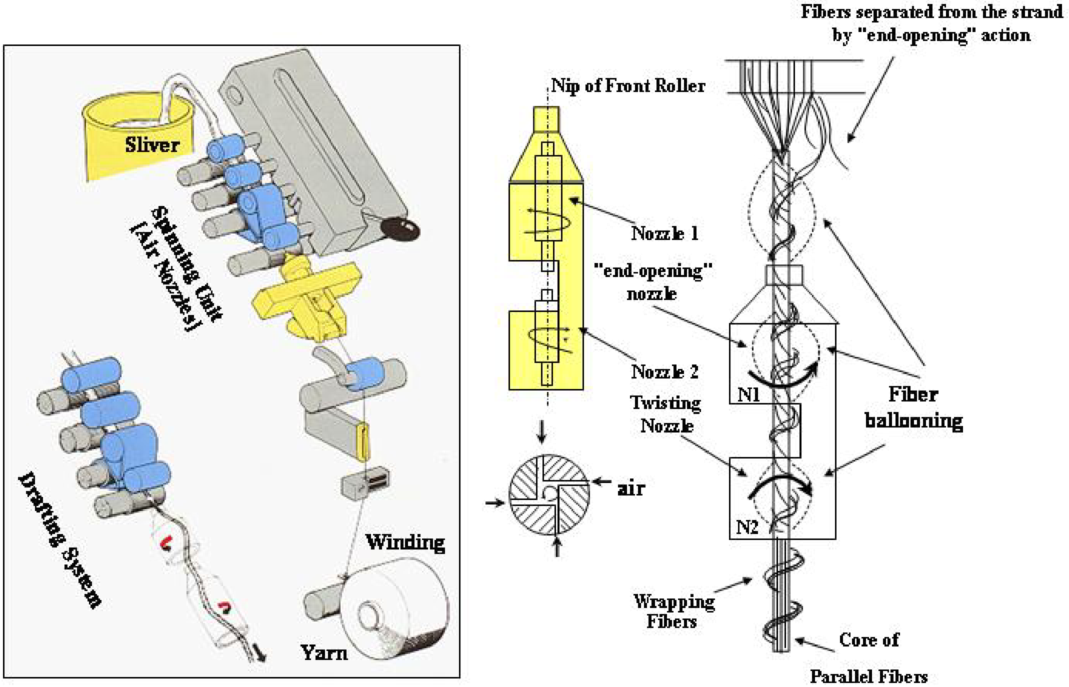


Figure 15. Murata Air-Jet Spinning (MJS) System.

In the conventional MJS system, the principle utilized results in a limited proportion of fibers in the sheath structure (about 10%). This makes this system limited to long staple fibers to provide the necessary wrapping (e.g. polyester fibers or cotton/polyester blends). In order to produce 100% cotton yarns on air-jet spinning, further developments were required. This has led to the introduction of the second generation of air-jet spinning, namely Murata Vortex Spinning (MVS) in 1998 under the commercial name “MVS851”.

This MVS (Figure 16) uses the principle of air vortex to produce a yarn similar in structure to that of the ring-spun yarn. The idea of this development is to improve two important features of the jet-spinning system: (i) the number of wrapper fibers, and (ii) the length of wrapper fibers. The key to this new system is the elimination of false twisting. However, the fibers run parallel and untwisted between the drafting system and the yarn forming point at the entry of a non-rotating spindle. As in the conventional MJS, a finished drawn sliver is directly fed to a roller drafting system, similar to that used on the MJS system. The drafted fibers are passed through a single air-jet nozzle and hollow spindle. Fibers exiting the nip of the front rollers are sucked into a spiral orifice at the entrance of the air nozzle, and they are then held together more firmly as they move towards the tip of a needle protruding from the orifice. At this stage, the force of the air stream twists the fibers. This twisting motion tends to flow upwards. The needle protruding from the orifice prevents this upward propagation (twist penetration). Therefore, the upper portions of some fibers are separated from the nip point of the front rollers but they are kept open.

After the fibers have passed through the orifice, the upper portions of the fibers begin to expand due to the whirling force of the jet air stream and they twine over the hollow spindle. In other words, some fibers are thrown around the spindle entry by the compressed air vortex, forming a true twist sheath. The fibers twined over the spindle are whirled around the fiber core and made into MVS yarn as they are drawn into the hollow spindle. This mechanism allows a proportion of 20% to 30% of wrapper fibers around the untwisted core. This enables 100% combed cotton to be produced on MVS, and 100% carded cotton with enough fiber length and acceptable fiber fineness. The finished yarn is wound onto a package after it is cleared using defect detector. Thus, the consolidation of fibers is achieved by applying a rapidly spiraling flow of compressed air at a non-rotating spindle tip in the air nozzle.

One of the spinning parameters that influence the physical characteristics of MVS yarn is the distance between the nip of the front roller and the tip of the spindle (distance L in Figure 16). The larger this distance is, the more the “upper portion open” fibers, resulting in a yarn of characteristics similar to those of truly twisted yarns. If the distance is too large, the waste fiber rate will also be extremely large. Murata suggests a distance that is slightly shorter than the average length of fibers.

In the context of fiber attributes, two fiber properties are critical to the new MVS: short fiber content, and dust content. The MVS system removes a great deal of short fibers. The waste percent can be as high as 8%, mostly short fibers. This gives the yarn a combed-like surface structure.

In ITMA 1999, Paris, the MVS machine was exhibited with 32 spindles continuously producing a 100% cotton yarn at 350 m/min production rate. This corresponds to about 310 gr/spindle hr (or 0.681 lbs/spindle hr). The sliver used was of 35 grains/yd size and made from cotton fibers that had a Micronaire reading of 4.0, UHML of 1.19 inch, length uniformity of 80.3, and fiber strength of 30.3 g/tex. The yarn exhibited was intended for woven fabrics such as sheeting, shirting, and print cloth. Some of the MVS yarn characteristics were also reported in comparison with other types of spun yarns. Tables 1 and 2 show values of MVS yarn characteristics in comparison with ring and open-end (rotor) yarns. These values indicate that MVS yarns have better uniformity values and lower levels of yarn imperfections than comparable ring-spun yarns and at approximately equal levels with rotor-spun yarns. They also have better strength and elongation values than rotor-spun yarns. MVS yarn was also found to have a relatively better surface definition and appearance (luster and uniformity) than conventional air-jet spun yarns and rotor-spun yarns. It was also found to exhibit slightly less torque or skew than ring-spun yarn, but similar to rotor-spun yarn.

Another important feature of MVS, which was inherited from the other MJS systems, is the balanced strength/count effect. Coarse yarns exhibit better packing, and more parallel core fibers. Fine yarns exhibit larger number of fiber wrappers. This effect results in approximately the same count-strength product for both fine and coarse yarns. In case of MVS, the finer the yarn count, the closer the yarn strength is to that of ring-spun yarn (see Figure 17).

Table 1. Comparison of Characteristics of MVS, Rotor, and Ring-Spun Carded Yarns using 100% Cotton (Mic = 4.2, UHML = 1.12 inch)-Murata Publications, 1999.

Yarn Quality	**MVS (Ne = 9.9's)**	**MVS (Ne = 16.3's)**	**MVS (Ne = 19.6's)**	**Rotor Yarn (Ne = 20.1's)**	**Ring-Spun (Ne = 20.1's)**
Uster C.V%	11.0	11.9	13.2	13.4	14.7
Uster Thin (-50%)	1	0	1	5	2
Uster Thick (+50%)	4	27	86	36	168
Neps (+200%)	45	38	96	64	114
Neps (+280%)	5	4	15	6	18
Uster Hairiness (H)	5.43	5.21	5.02	4.8	8.6
TensoRapid:					
Strength (CN/tex)	10.0	12.8	13.2	12.4	15.4
Elongation (%)	7.3	7.6	7.3	6.5	5.6
C.V% Strength	9.8	6.7	6.8	7.5	8.7
C.V% Elongation	9.3	5.5	4.8	7.5	5.4

Table 2. Comparison of Yarn Characteristics of MVS, Rotor, and Ring-Spun Carded Yarns using 100% Cotton (Mic = 4.2, UHML = 1.12 inch)-Murata Publications, 1999.

Yarn Quality	**MVS (Ne = 31.8's)**	**MVS (Ne = 39.5's)**	**Rotor-Spun (Ne = 32.4's)**	**Ring-Spun (Ne = 31.9's)**
Uster C.V%	16.3	18.8	15.3	16.8
Uster Thin (-50%)	88	417	59	27
Uster Thick (+50%)	181	413	101	376
Neps (+200%)	341	711	523	408
Neps (+280%)	40	89	93	77
Uster Hairiness (H)	4.5	4.03	3.6	6.6
TensoRapid:				
Strength (CN/tex)	14.1	13.7	12.2	16.8
Elongation (%)	6.3	5.5	6.0	5.3
C.V% Strength	6.5	9.8	8.4	7.1
C.V% Elongation	6.6	9.5	9.6	6.8

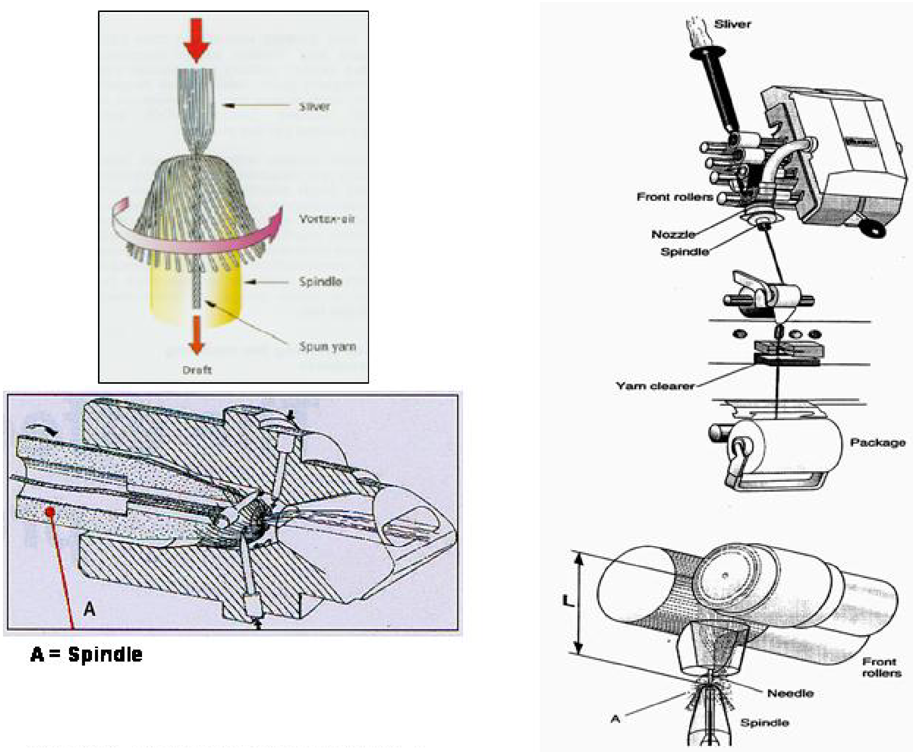


Figure 16. Murata Vortex Spinning (MVS®).

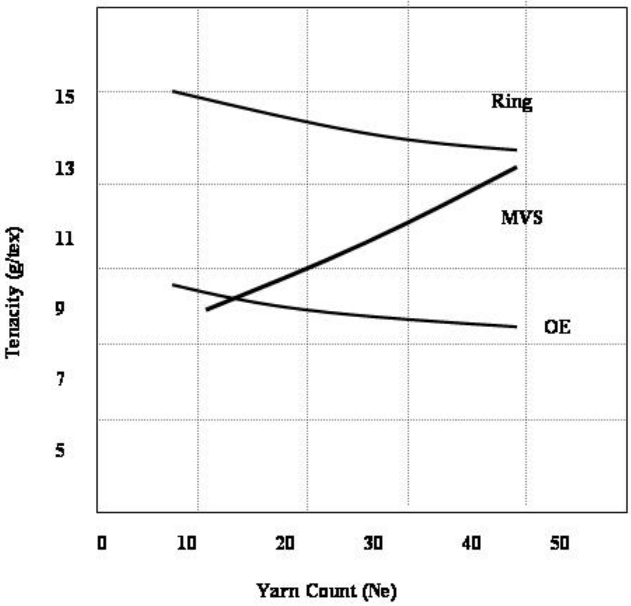


Figure 17. Murata Vortex Spinning (MVS).

MVS 861-Murata Vortex Spinning

At ITMA 2003, Muratec introduced its new Muratec (J) "Vortex" "MVS 861" model spinning machine with many improved features over its previous MVS 851 machine. In the MVS 861, direct cone winding is combined in ideal form with a yarn strengthening function and an efficient fault detection and control system. The new machine operates at a maximum speed of 450 m/min under practical conditions (more than 20 times faster than a ring spinning system), and offers many advantages including good yarn quality, maximum productivity, reduced energy consumption, and user friendliness.

Again, the MVS 861 is based on the "Vortex" air process, in which yarn from fibers circulating in the jet at the speed of sound are produced with real twist by the take-up roller. As no mechanical twist process takes place in the train of the yarn production process, the spun yarn can run significantly faster than on a conventional ring spinning system. Murata reported many quality features with the new MVS system including: low hairiness, fewer pills, softer handle and a more compact structure.

The "MVS 861" can wind staple fiber yarns on to cones with an angle of up to 5° 57 and traverse lengths of 127 mm and 146 mm. The cone angle can be adjusted as required. One important aspect here is that the shape of the cone does not reduce winding speed. There is also a rotor winding system which winds cones with an angle of up to 4° 20, though winding speeds are limited in this case. Successful cone winding at speeds up to 450 m/min has been made possible therefore by Murata's integrating the "Process Goner's" winding elements and yarn reinforcement units in a spinning process, enabling winding speed to be increased.

Other mechanical improvements involve the installed power supply of 25.5 KW/80 spindles (0.319 KW/spindle), achieving energy savings of up to 25%. The air volume required is 58 NL (normal liters)/min/jet at 0.5 MPa, which is equivalent to a 27% reduction in energy consumption as compared with the existing model, The newly installed VOS ("visual on demand") operating console system, which is used for easy traction (yarn speed) speed control and various other spinning parameters, increases machine operator friendliness. Important VOS System components are easy machine starting plus yarn quality and operating parameter control. No yarn faults such as smaller thick places for example, which can be continuously detected during processing, escape the digitally controlled fault detection system for all spindles.

MVS yarns produced by "Vortex" air jet spinning have numerous quality features in consequence of the special yarn production process, due to fiber circulation in the jet and twist automatically produced without direct mechanical twist force effect. The most important advantages include:

- Significantly less hairiness, which is reduced by about 12 to 15% compared with ring yarn and is even better than with compact yarn.
- Excellent anti-pilling properties - high moisture uptake and quick drying.
- High productivity in subsequent woven fabric production processes plus a spinning speed 14 times higher than in ring spinning.

On the other hand, yarn strength is relatively lower, and woven fabric handle is a little rougher than with ring yarns. Table 3 shows comparison between MVS 861 polyester yarn and other polyester yarn types as reported by Murata using ring-spun yarn as a reference (100%). The productivity index shown in Table 3 is based on a test conducted with the conventional MVS machine at a speed of 300 m/min. Murata emphasized that the index would be 1.5 times higher if an "MVS 861" comparative value at a speed of 450 m/min were to be applied. It was further remarked that MVS yarn has visibly lower hairiness and better pilling resistance than compact yarn, which was regarded, with these two parameters, as the leader before MVS yarn appeared on the market.

Table 3: Comparison of yarn quality with different spinning systems. [Test yarn: 30's, 1.3 d, 38 mm, 100% polyester]

Parameter	MVS	Ring	Compact
Hairiness (1 mm)	13	100	83
Hairiness (3 mm)	6	100	52
Hairiness (5 mm)	14	100	43
Max. Strength	80	100	104
Min. Strength	76	100	108
Elongation	82	100	104
Pilling Rate	4	1-2	2-3
Productivity Index	1430	100	104

Rotor Spinning

For those who are unfamiliar with rotor spinning, it represents another high-speed spinning that has been in continuous development for more than thirty years. It consists of a drafting mechanism, a consolidation mechanism, and a winding mechanism. However, these three mechanisms are substantially different from those used in ring spinning. The differences are driven by two important goals, which have been set since the introduction of this unique spinning system:

- To completely dispense the roving process and directly feed a drawn or a carded sliver to the spinning process
- To break the linkage between twisting and winding to overcome the problem of low production rate and allow the production of large size package.

In rotor spinning, the drafting mechanism consists of three main operations: (i) mechanical opening using an opening roll, (ii) air drafting using an air stream and transporting duct, and (iii) consolidation mechanism. The use of a sliver requires a large amount of draft to reduce its size down to that of the yarn size. A sliver may have more than 20,000 fibers per cross-section. Before this number of fibers is reduced to a value of about 100 fibers per cross-section in the yarn, it must first be reduced to as low as two fibers (a draft ratio of 10,000:1). This substantial reduction requires high-speed mechanical drafting boosted by air drafting (Figure 18).

The mechanical drafting is achieved using a toothed opening roll. This opening roll separates the fibers in the sliver and allows removal of trash. Fibers coming out of the opening roll are airborne through an air duct. This zone of draft is of special significance because of its impact on fiber orientation. A turbulent airflow will result in some fiber disorientation. This could partially result in a weak yarn.

In order to minimize fiber disorientation, the airflow in the duct should have a velocity exceeding that of the surface speed of the opening roll. To obtain such an airflow, the inside of the rotor is run at a vacuum which may be achieved by designing the rotor with radial holes to allow the rotor to generate its own vacuum (self-pumping effect). Alternatively, an external pump can be used. Fibers in the duct should have a smooth and straight flow. Therefore, the air duct may be designed in a tapered shape toward the rotor to allow acceleration of the fibers as they approach the rotor inside surface. This action also allows straightening of leading fiber hooks coming out of the opening roll.

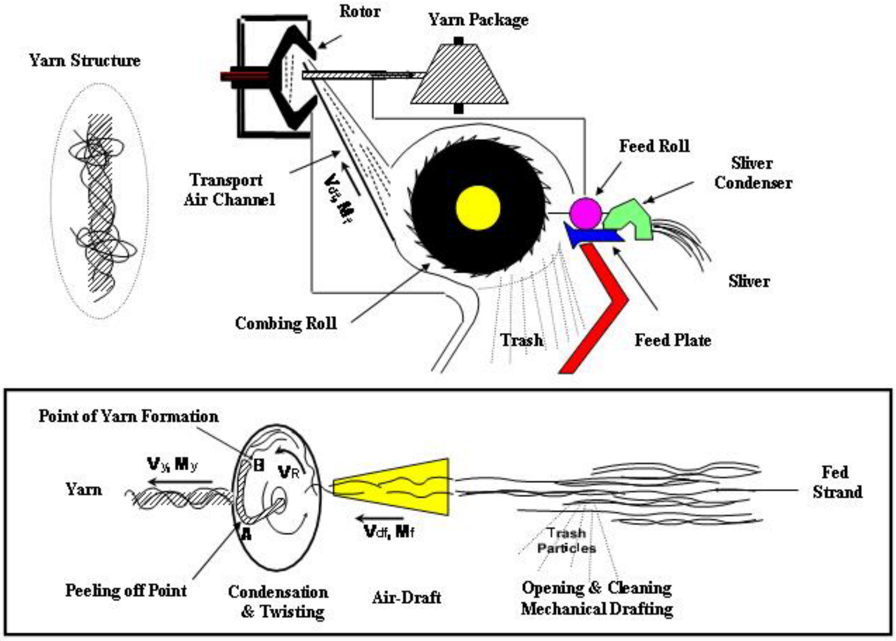


Figure 18. Principle of Rotor-Spinning.

The number of fibers per yarn cross-section is a function of the number of fibers landing inside the rotor, fiber velocity, and the yarn velocity. The effect of the air drafting described above is to reduce the fiber strand down to few fibers (2-10 fibers). These fibers are then landed into the inside surface of the rotor as it takes many layers of fiber to make up sufficient number of fibers per yarn cross-section. As successive layers of fibers are laid into the inside surface of the rotor, a doubling action occurs. This action tends to even out short-term irregularities in the yarn. This back-doubling action, along with the elimination of roving leads to a yarn of higher evenness than that of the conventional ring-spun yarn.

The consolidation mechanism in rotor spinning is achieved by twist insertion resulting from the high-speed rotation of the rotor. The applied torque on the fibers lying inside the rotor groove depends on a number of factors including: the number of fibers per cross section, fiber stiffness, and rotor speed. The actual torque transmitted to the fibers depends on the yarn tension at the point of yarn formation (point B in Figure 18), the yarn radius, and the twist factor. Every turn of the rotor produces a turn of twist, and a removal of a length of yarn of 1/tpi inches. Thus, the amount of twist is determined by the ratio between the rotor speed and the yarn delivery speed.

One of the fundamental differences between rotor spinning and ring spinning is the lack of tension differential in rotor spinning. For example, the tension at the yarn formation point (B) is typically less than 4 cN at a rotor speed of 100,000 rpm, and a yarn count of 30's. This low tension results in two effects: (i) it has a tendency to reduce yarn strength because of the low fiber migration, and (ii) it results in low actual torque required to twist the fibers. Accordingly, actual torque transmitted to rotor spun yarn may be less than the applied nominal torque. Generally, this effect calls for higher twist for rotor-spun yarns than for ring-spun yarns. In addition, it contributes a great deal to the fact that fine yarns cannot be spun efficiently on rotor spinning. In principle, rotor spun yarns need more fibers per cross-section than comparable ring-spun yarns due to the insufficient torque at the point of yarn formation.

In light of the above discussion, it follows that for the rotor-spinning system to meet an optimum twist that satisfies comfort and strength criteria, fiber properties should be carefully selected. In other words, rotor spinning imposes higher constraints on fiber characteristics than ring spinning.

The winding mechanism in rotor spinning is separated from the drafting and the consolidation mechanisms. The yarn package is no longer the rotating twisting element as in ring spinning. The rotating twisting element is the rotor, which is of very small size. This allows much higher speed in rotor-spinning than in ring spinning, and consequently higher production rates. Furthermore, there is no limitation on the size of yarn package; this eliminates further winding of yarn for weaving preparation.

Rotor Spinning at ITMA 2003

At ITMA 2003, developments in rotor spinning represented a continuation of improvement of the mechanical and control features of the system. The only system that I was able to recognize in the exhibition was the new Savio FlexiRotor S300. The system represented a slightly further development from existing systems and it was perceived as a continuation of the well-developed Rieter R40 machine. The machine utilizes the familiar twin-disc bearing system and it has two independent sides. In the exhibition, one side was running yarn of Ne 30's with a 28 mm rotor running at 150,000 rpm and the other side was running a coarser yarn of 6's with a 40 mm rotor running at 85,000 rpm. This machine can have up to 320 rotor positions with the use of up to four doffing and piecing trolleys. Yarn packages of up to 6 kg weight can be produced at precise preselected density with flexibility allowing a transition from cylindrical to conical shape packages (up to 2^{o} using an adapter).

SC-R Rotor Spinning Box

One cannot speak of rotor spinning development without mentioning Rieter rotor spinning despite its absence from ITMA 2003 exhibition. Indeed, Rieter R 40 is considered as the most developed machine of its type in today's technology. This machine uses the SC-R spinning box, which is based on the experience, gained from manufacture and installation of 2.5 million spinning boxes. This spinning box is believed to have set new standards in running properties and yarn quality. Features of the SC-R spinning box include (see Figure 19):

- The opening roller is constructed as a solid ring of 64 mm diameter for cotton and man made fibers, for economical replacement and with optimized tooth shapes for opening fibers without damage
- Flexible open arrangement of the opening rollers prevents clogging in the region of the cover
- Steel rotors of diameter 28 mm to 56 mm for all rotor-yarn applications
- Highly effective wear resistance for long life-time and constant yarn quality
- Special designs for particular types of yarn
- Easily removable channel inserts for rapid adjustment to the rotor diameter, optionally with SPEEDpass.
- Draw-off nozzles are made from high-quality ceramics for a wide range of yarn structures and with magnetic holder for replacement without tools
- Nozzles with special ceramic inserts for knitting yarns similar to ring-spun yarns
- Ceramic nozzles for protective processing of man made fibers and blends at high rotor speeds
- Easily removable TWISTstop inserts to improve spinning stability and for manufacture of soft-twisted knitting yarns.
- Fast lot changes without tools: all the spinning elements of the SC-R spinning box are very easily removed and reinstalled.
- An opening unit developed specially for man made fibers very easily replaces the entire opening unit.
- Draft, twist and winding tension are infinitely adjustable at the R 40's control panel
- It is not necessary to stop the machine or to change the gears or belt for fine-tuning of yarn count or yarn twist.
- Rotor speed and, optionally, the speed of the opening roller are infinitely adjustable by means of inverter drives; the manual work involved in lot-changing is therefore limited to can changing with new feed material.
- When the SC-R box is opened the feed-drive gear remains engaged so that the risk of damage associated with decoupled drives is eliminated.
- The modular spinning box concept offers the alternative of using an opening unit for man made fibers, which allows more reliable separation of the fibers from the clothing of the opening roller. A channel insert equipped with SPEEDpass assists this separation and ensures uniform feeding of the fibers into the rotor.
- BYpass for individual adjustment of the incoming air stream at the trash-removal unit.
- The cleaning intensity can be adapted individually for the feed material used.
- Fixed fiber-beard support and movable feed table for uniform sliver opening even in the event of variations in sliver cross-section.

- A distinctive feature of the SC-R spinning box is the open design of the opening roller, which is sealed from the environment by a patented step seal. This facilitates replacement of the roller and has also eliminated the problems caused by fibers accumulating near the covers.
- The accessibility of the SC-R spinning box is clearly superior to that in other systems; opening unit is simple and extremely fast.

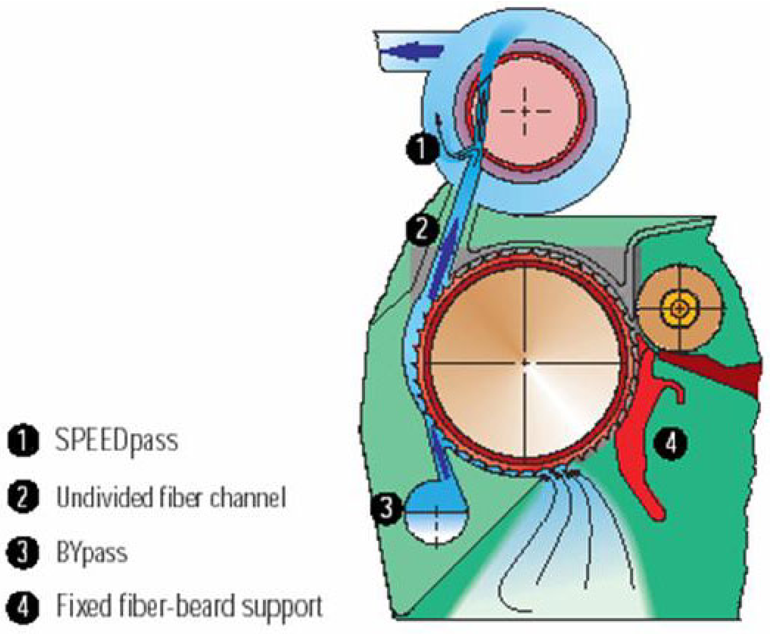


Figure 19. SC-R Spinning Box with SPEEDpass.

Automation and Control Features

In the R 40 rotor-spinning machine Rieter offers many automation concepts. The modularly constructed robot, integrating piecing and package changing functions, has been continuously optimized over several years. The key feature is integrated automation. In this regard, all the important functions – rotor cleaning, piecing, and package changing – are combined in one robot. Package hanging and piecing are carried out in a single pass. The individual function steps in the modularly constructed robots run parallel to a large extent. Cycle times are consequently very short, thus contributing to high machine efficiency. As a result of the use of the UNIfeed® tube-supply system, the robot is supplied with an empty tube before each package change. In addition, all the functional units in the R 40 robot work with precision-controlled pneumatic systems and individual drives. Every unit is an individual, independent functional device that can be quickly and easily replaced if required. For maintenance and service personnel, the clear layout of the functional units is an important plus.

Adjustments to lots are handled by quick, easy and user-friendly operation directly at the control panel. Precise, contact-less positioning of the robot using frequency-controlled traverse drive and laser control reduces wear on the traverse drive. Special module of the robot is prepared for efficient cleaning of the rotor and the nozzle at every piecing cycle.

BT 903 Semi-Automatic Rotor Spinning Machine

Full automation is typically justified in countries experiencing high labor cost where expensive fully automatic machinery substitutes for high labor cost. When labor cost is not an issue, economy and less automated machines are desirable. For this reason, Rieter offered the partially automated BT 903 rotor machine. This machine is equipped with the so-called “AMIspin” system in which each spinning position is equipped with mechanical and electronic yarn break repair elements. Some of the features of the BT 903 are as follows:

- Integrated optical yarn clearer IQclean® by Rieter, which controls thick places with 6 channels, thin places with 2 channels, moiré effect and yarn count variation.
- The AMIspin® semiautomatic piecing system allows a quick and easy piecing in 15 seconds. The piecing process is controlled electronically.
- Increased piecer strength with the Qtop®-device, which eliminates damaged fibers from the sliver.
- Machine length up to 320 spin boxes
- New rotor bearing technology, which allows to run the rotors with speeds up to 100 000 rpm

- Using new vacuum type rotors without ventilating holes, the lifetime of the rotor bearings is extended when spinning at high rotor speeds.
- Winding speed of BT 903 is up to 175 m/min
- Independent side drives allow processing of two different yarn materials or yarn counts or colors on each side and increase the flexibility of the mill substantially.
- Stepless setting of yarn count, twist and winding speed with frequency inverters speeds up lot changes.

Closing Remarks

This two-part review of current developments in spinning preparation and yarn forming machinery raises a number of questions and critical points that I believe will represent major issues in the coming years. In summary, these are as follows:

Economical Issues:

- How to develop machinery that is highly advanced yet inexpensive?
- Will U.S. machinery makers continue to disappear?
- Will European machine makers give way to Asian competitors?
- Will European machinery makers seek joint venture with Asian partners?
- Would Asia (China & India) get heavily involved into the textile machinery business?
- What is the global future of the American Cotton?
- How about the American Cotton Logo. How effective it will be in a global market?
- What target markets of potential business to seek?
- Would cotton continue to survive in a global market full of innovative synthetic fibers?

Technological Issues:

- How compacted the spinning technology will be in the next few years?
- How new developments accommodate mixing of extreme cotton varieties with different quality levels and contamination contents?
- Would we see a call for standard global cotton production methodology?
- Would we see a two step-operation of fiber-to-yarn conversion?
- Will developments shift completely toward more quality-oriented machinery at the expense of speed and automation?
- Will simpler technology prevail to accommodate poorly-skilled labor particularly in process control and manipulation?
- Will smart system (operator's skill robust) and semi-automated and Self-adjusted machinery prevail to reduce cost?
- How to achieve more end-product-oriented technology?

I would hope that by the next ITMA in Germany, we will find answers to these questions. Indeed, I would hope that the coming ITMA in Germany will be held, and under better economical environment and global prosperity.

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