The Rieter Manual of Spinning
Volume 4

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Volume 4 – Ring Spinning

Werner Klein
Dr. Herbert Stalder

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G 36 ring spinning machine

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Volume 4 – Ring Spinning

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THE RIETER MANUAL OF SPINNING

Volume 1 – Technology of Short-staple Spinning

This deals with basic, generally valid, technological relationships in short-staple spinning. Subsequent volumes are organised according to machines or machine groups. This separates generally valid basic principles from ongoing developments in machine design and construction.

Volume 2 – Blowroom & Carding

In-depth information is provided on opening, cleaning, blending and carding and additional aspects are covered such as acclimatisation of raw materials, anticipated waste from various grades of fibre, selection and setting of cleaning and blending machinery, waste recycling, transport and the functions of the various card components as well as selection and maintenance of card clothing and autolevelling systems.

Volume 3 – Spinning Preparation

Here the technical and technological aspects of the yarn production process between carding and ring spinning are covered, that means draw frame, combing section (including combing preparation) and roving frame. This is an important process stage, because the yarn quality largely depends on the quality of the intermediate products from which it is made.

Volume 4 – Ring Spinning

Technical and technological aspects of ring spinning are covered. This is the final process in yarn production. The ring spinning machine greatly influences the yarn and its quality. Ring-spun yarns still represent the standard for comparison when evaluating yarns produced by other spinning processes.

Volume 5 – Rotor Spinning

This process resulted from research into alternative spinning systems. This volume contains in-depth information on the rotor spinning process and its properties. Continual improvements in spinning elements and conditions make it now possible to spin a rotor yarn optically similar to a ring-spun yarn.

Volume 6 – Alternative Spinning Systems

To take full advantage of alternative spinning systems, a thorough understanding of them is therefore essential. This volume contributes towards reaching this goal by describing the most important alternative spinning systems in detail. One of them is the well known Air-jet spinning technology.

Volume 7 – Processing of Man-Made Fibres

Ever since the introduction of man-made fibres on a commercial scale, the market share of synthetic fibres has shown an impressive growth rate. In this important field, the variety of man-made fibres with different properties is continuously increasing. For numerous applications today, fibres that are practically “tailor-made” are available. Spinners must therefore have detailed understanding of the fibre properties and the specific characteristics that affect their processing.

EDITORIAL

Ring Spinning Machine is the forth volume in the series The Rieter Manual of Spinning, which updates the essential principles in modern short-staple spinning. It endeavors to describe the contemporary state of the art in spinning technology, with the objective of providing a reliable overview of currently available processes and techniques.

It deals with ring spinning engineering and technology. This is a very important segment of yarn manufacturing, since ring spinning has a very considerable influence on the productivity of the whole process and the quality of the yarn. Ring spinning is still the quality standard benchmark for any new spinning processes. The importance of this universal process is confirmed by the 200 million spindles installed worldwide and by their 80 % share of yarn production in the short staple segment. Impressive advances in performance that have been achieved in recent years as well as striking improvements in yarn quality made possible by the compacting technology, will ensure its dominant market position in the years to come. A fundamental and detailed understanding of the operations involved in the creation of yarn is of crucial importance for all specialists in the spinning industry and textile engineering, as is the close interdependence of the different functions of the process. If material and equipment are to be exploited to their limits – the precondition for surviving in today‘s very tough competitive environment – these limits have to be known. As in the other volumes in this series, an introduction familiarizes the reader with the subject matter as such. The individual elements and their functions are dealt with in the same way, as well as the different influences they exert on the process and quality.

The main author of these books, Werner Klein, is a former senior lecturer of the Swiss Textile College and author of the original edition of the „Manual of Textile Technology“ published by The Textile Institute Manchester. All further authors are textile industry experts, who among others in various positions within the Rieter Company, have many years of experience to their credit.

The structure of this manual and the organization of its subject matter were taken over from the original Technology of Short-staple Spinning published by the Textile Institute, Manchester, whom we thank for their kind permission to continue this standard work.

It is also pointed out again here that some important technological fundamentals have already been dealt with in The Rieter Manual of Spinning, Volume 1 – Technology of Short-staple Spinning, especially drafting and the interaction of the ring and traveler.

We wish all users of this compendium pleasant reading.

Rieter Machine Works Ltd.

CONTENTS

1. THE RING SPINNING MACHINE

1.1. Introduction

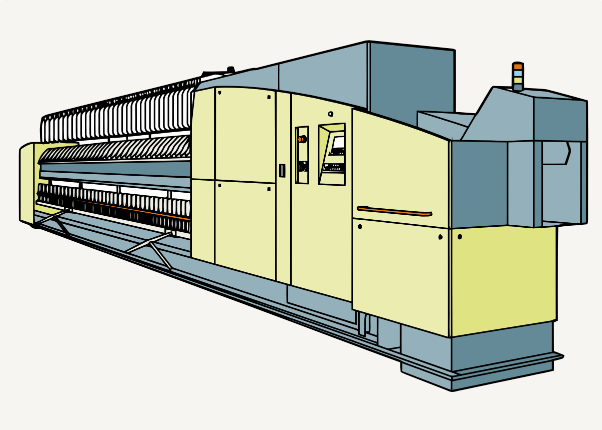


Fig. 1 – Ring spinning machine

The ring spinning machine was invented by an American named Thorp in 1828, and Jenk – another American – added the traveler rotating around the ring in 1830. In the intervening period of more than 170 years the ring spinning machine has undergone considerable modification in detail, but the basic concept has remained the same. For many years any noteworthy further development hardly seemed possible, yet a significant process of evolution took place during this time. The productivity of the ring spinning machine has increased by 40 % since the late nineteen-seventies. This has been achieved by:

- using smaller rings and cop formats;
- introducing piecing in the winding department;
- substantial improvements in rings and travelers.

The degree of automation has also been increased significantly. As this process of evolution is not yet complete, the ring spinning machine will continue to be the most widely used spinning process in short staple spinning, since it has considerable advantages over the new spinning processes:

- it can be used universally, i.e. any material and any yarn count can be spun on it;
- it produces yarn with optimum properties (especially as regards structure and tenacity);
- it is uncomplicated and easy to control;
- know-how for handling the machine is old, well established and accessible to everyone;
- it is flexible with regard to volume (blend and batch sizes).

New spinning processes therefore often find it difficult to make a substantial breakthrough (with the exception of rotor spinning, and most recently Air-jet spinning). Due to their many inherent limitations, the new processes are only ever to be found in sub-segments of the market, usually in the coarser yarn sector. The current renaissance of the ring spinning machine is due to the fact that these inherent features have been clearly recognized by specialists. However, the ring spinning machine can only hold its own position in the long run if the ring spinning process can be automated further and spinning costs substantially reduced, since this machine is a major cost factor in a spinning mill, as the graph produced by Rieter shows (Fig. 2).

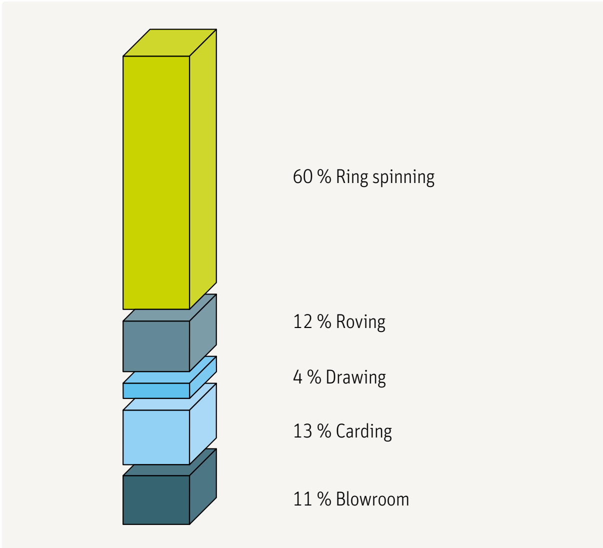


Fig. 2 – Cost structure in a typical ring spinning mill

Improvements can be achieved primarily by:

- further development of rings and travelers
- using automated take-off devices (doffers)
- reducing the ring diameter, which enables the rotation speed of the spindle to be increased while traveler speed remains unchanged. For example, cost savings of some 7 US cents/kg of yarn are achieved by using a 42 mm ring instead of a 48 mm ring, despite a slight decline in efficiency. However, reductions in ring diameter presuppose the use of doffers on the ring spinning machine (except when wage costs are very low) and piecers on the winder. The slub-free length is then of little importance.
- increasing machine length, which reduces the machine price
- reducing ends down frequency, in which the new data collection systems and new drive systems can be of great assistance
- improving roving quality, since the causes of at least 50 % of all ends down on the ring spinning machine are to be found in the preparatory machines

- combining the ring spinning machine and the automatic winder into a production unit
- roving stop motions, primarily for reducing waste and preventing laps; they could perhaps enable operations to be maintained with fewer personnel during certain working periods
- automation in the fields of roving bobbin transport and roving bobbin change.

Altogether, these can make the ring spinning machine a very attractive proposition again. Technological relationships are explained in detail in Volume 1.

2. FUNCTION AND MODE OF OPERATION

2.1. Task

The ring spinning machine has to:

- draw the roving to its final count in the drafting system;
- impart tenacity to the bundle of fibers by twisting it; and
- wind up the resulting yarn in a suitable form for storage, transport and downstream processing.

2.2. Operating principle

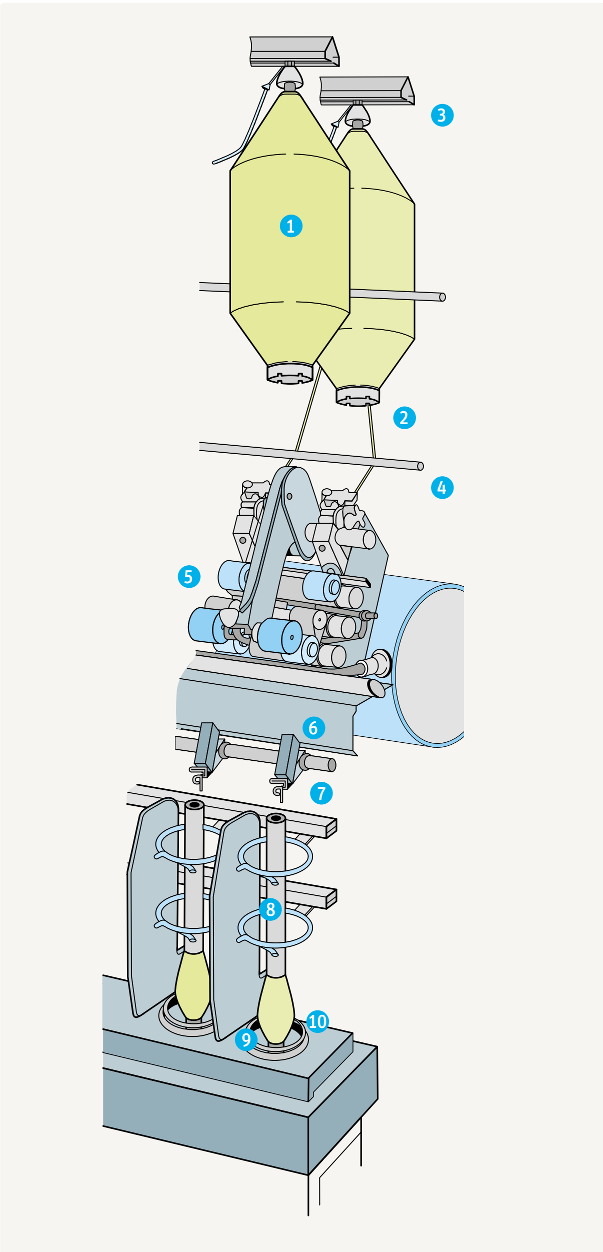


Fig. 3 – Working diagram

The roving bobbins (1) are inserted in holders (3) on the creel. Guide bars (4) guide the rovings (2) into the drafting system (5), where they are drawn to their final count. The drafting system is at an angle of 45 - 60° and is one of the most important units on the machine, since it exerts a very considerable influence on the uniformity of the yarn in particular.

After the resulting thin ribbon of fibers (6) leaves the delivery roller, the twist necessary for imparting strength is provided by spindle (8) rotating at high speed. In the process each rotation of the traveler on the spinning ring (10) produces a twist in the yarn. Ring traveler (9) is also necessary for taking up this yarn onto a tube mounted on the spindle. This traveler – a remnant of the flyer on the roving frame – moves on a guide rail around the spindle, the so-called ring (10). The ring traveler has no drive of its own, it is dragged with spindle (8) via the yarn attached to it. The rotation of the ring traveler lags somewhat behind that of the spindle due to the relatively high friction of the ring traveler on the ring and the atmospheric resistance of the traveler and the thread balloon between yarn guide eyelet (7) and traveler (9). This difference in speed between the spindle and the traveler results in the thread being wound onto the tube. In contrast to the roving frame, the ring spinning machine spindle operates with at higher speed than the traveller (9).

The yarn is wound up into a cylindrical cop form by raising and lowering of the rings, which are mounted on a continuous ring rail. The layer traverse of the ring rail is also less than the full winding height of the tube. The ring rail therefore has to be raised slightly (shift traverse) after each layer has been wound. For a time, machines were also built featuring shift traverse produced by lowering the spindle bearing plate rather than raising the ring rail. These machines are no longer available today.

3. STRUCTURAL CONFIGURATION OF THE MACHINE

3.1. Basic frame and superstructure

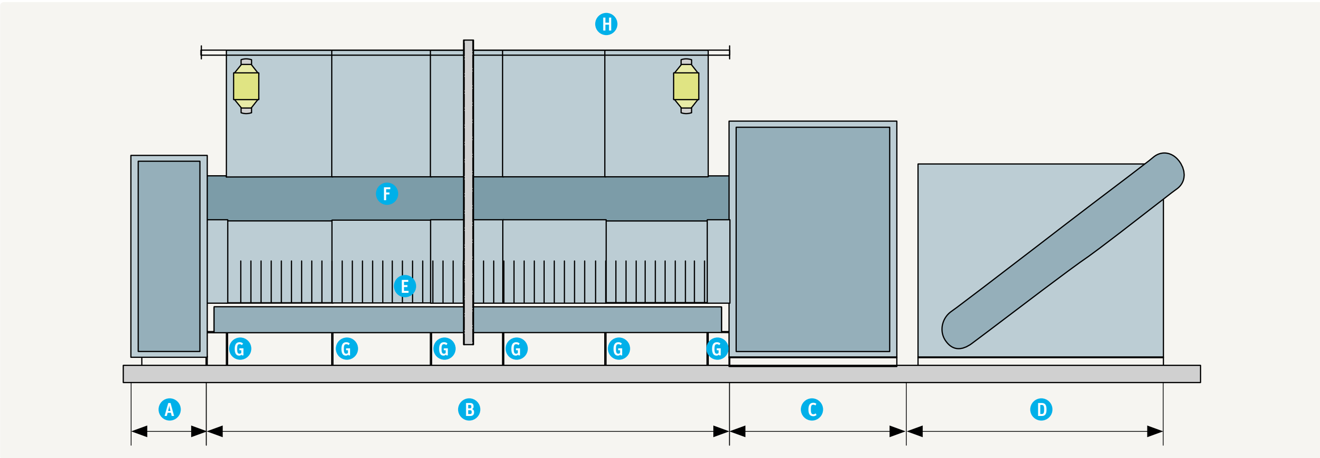


Fig. 4 – Machine components

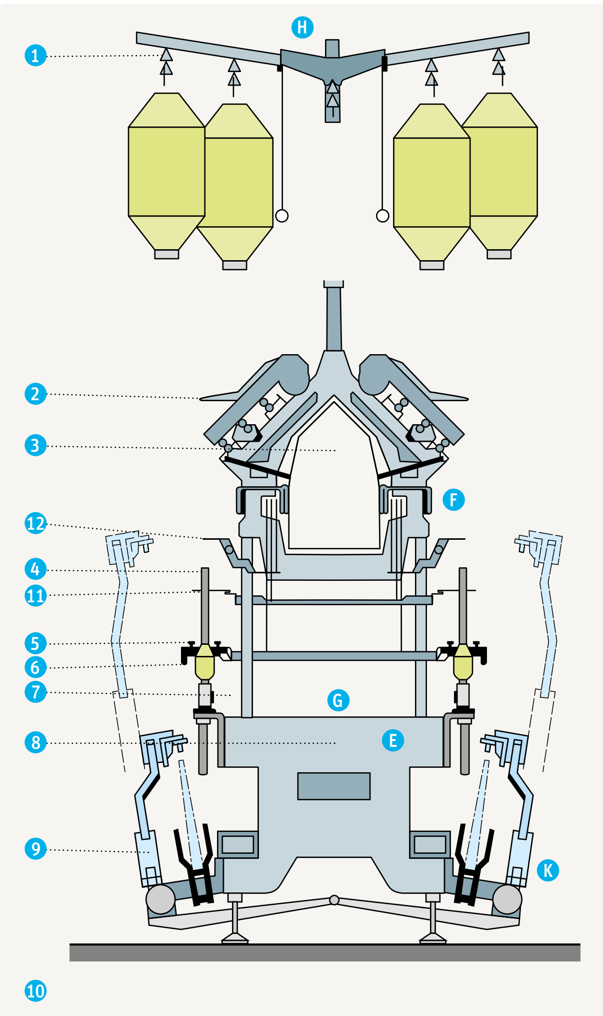


Fig. 5 – Section through the machine

The long, manufacturing mid-section of the machine (B) consists primarily of continuous longitudinal spindle bearing plates (E) and cylinder supports (F) along its entire length, which are attached to several center frames (G) arranged at short intervals. The latter also serve as supports for the bobbin creel. Spindles (4) are mounted on the spindle bearing plate, drafting system (2) on the cylinder support. Each center frame stands on two feet which can be adjusted in height by screws, which facilitates leveling of the machine.
End stocks (A+C) at each end of mid-section (B) can accommodate, for example, the transmission, electrical and electronic components, and the drive and the thread extraction filter, respectively. Modern machines also include the automated take-off unit (doffer, D). Including the doffer, machine width varies between approx. 800 and 1 000 mm (up to 1 400 mm with doffer arm extended), and nowadays the length can be up to 50 m and more, with up to 1 600 spindles per machine. Spindle gauge is usually between 70 and 90 mm.

3.2. The bobbin creel

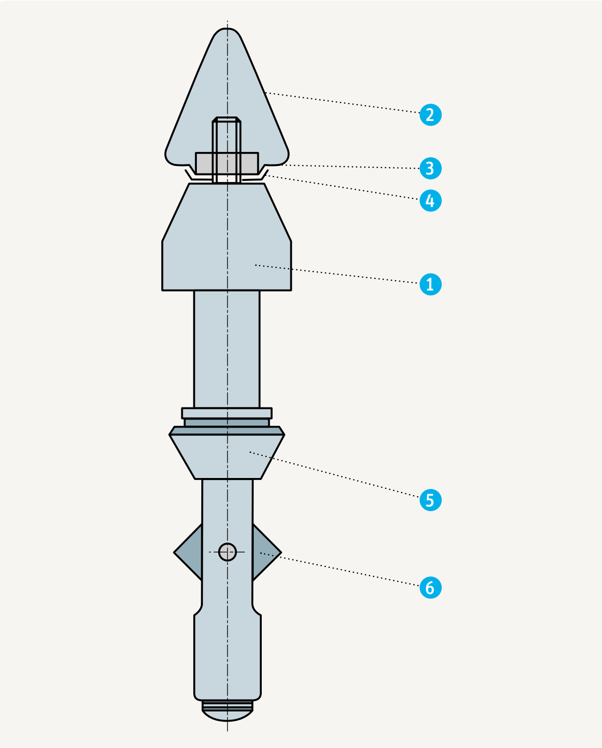


Fig. 6 – Bobbin suspension pivot

The bobbin creel is simple in design, but it can nevertheless have an influence on the occurrence of faults. If take-off from the bobbin is not trouble-free, incorrect drafts or even thread breaks occur. This is why bobbin suspension pivots are used nowadays rather than bobbin holders. These are, for example, bolted onto several support rails (triangular tubing (2)) arranged one behind the other along the entire length of the machine, one for each spindle. The pivots, such as the Casablancas model illustrated, feature the actual holding device for the tube in their lower section (6).
If ring (5) is pushed right up with the top end of the tube inserted in the pivot, retainer (6) for the bobbin swings out; if ring (5) is pushed upward a second time, holder (6) is retracted again, and the tube, for example when it is empty, can be removed again. The pivots are mounted in ball bearings. A light brake hoop occasionally presses gently against the bobbin so that the bobbin cannot rotate too fast. This braking device is integrated in the bearing unit on modern suspension pivots.
Nowadays bobbin creels occupy lots space in terms of width, as very large roving bobbins are usually used.

3.3. The drafting system

3.3.1. Influence on quality and economy

If an assessment is based on quality alone, the drafting system is the most important part of the machine. It primarily influences the uniformity and tenacity of the yarns. The following aspects are therefore very important:

- the type of drafting system;
- its design;
- precise settings;
- choice of the correct components;
- choice of the correct drafts;
- maintenance and servicing, etc.

However, the drafting system also has an influence on economy, i.e. directly via ends down frequency and indirectly via degree of draft. If higher drafts can be set in the drafting system, this enables coarser rovings to be supplied. However, coarser rovings signify in turn higher production performance of the roving frame and thus savings on roving spindles, i.e. a reduction in machines (roving frames), space, personnel, etc. However, if the draft is increased too much, this can result in a reduction in yarn quality. The following approximate upper limits for drafting have emerged in mill operations using modern drafting systems with good fiber guidance (e.g. Rieter drafting systems with P 3.1 pressure arm):

- carded cotton yarn up to 40
- carded yarn blends up to 50
- combed cotton and blended yarns
  - medium counts up to 60
  - fine counts up to 70
  - manmade fibers up to 45 (- 50).

In order to obtain optimum results, the break draft zone must be set in such a way that the roving is under tension in this zone, but only sufficiently for no real drafting to occur. This is achieved with break draft nip distances of 60 - 80 mm and break draft settings of 1.03 to about 1.3. Unfortunately, generally applicable optimum settings for every case cannot be stated, since they depend heavily on fiber material, roving count and roving twist.

3.3.2. Conceptual structure of the drafting system

3-roller, double-apron drafting systems are used exclusively on modern ring spinning machines used for short staple spinning. They consist of three fluted, driven, bottom steel rollers (a) with top rollers (b) positioned above them, supported and pressed against bottom rollers (a) by a rocking support (c) (pressure arm). Since a fiber bundle with only few fibers has to be transported in the main drafting zone, the main drafting zone is provided with a guide unit consisting of rotating bottom and top aprons (e).

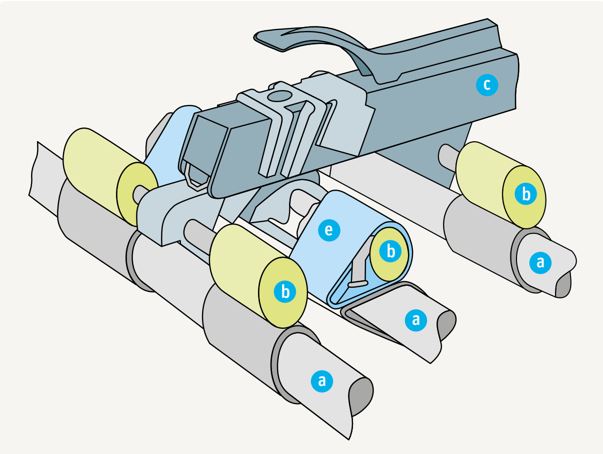


Fig. 7 – The drafting system

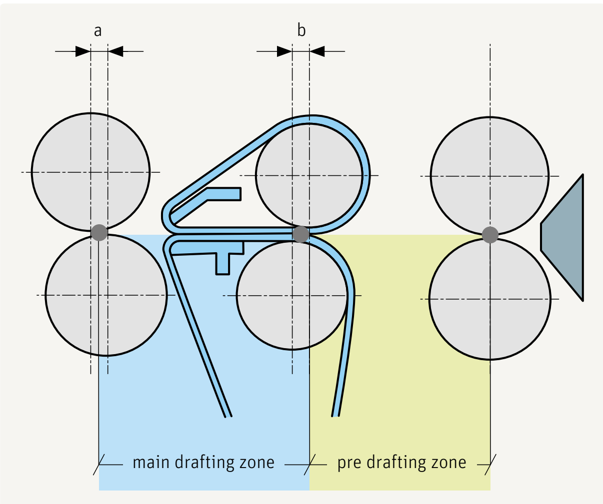


Fig. 8 – Section through the drafting system

The top rollers are usually arranged as shown in Fig. 8. An overlap (a) of 2 - 4 mm is usually selected for the front rollers and an underlap (b) of 2 - 4 mm for the middle rollers. The overlap and underlap ensure smooth running of the top rollers, and the overlap of the front roller also shortens the spinning triangle by advancing the nip line (refer to „Spinning geometry“), which has a correspondingly positive impact on ends down frequency. Another roller configuration has been offered by the INA company in the so-called V-Draft drafting system. In this case the rear top roller is shifted to the rear on the bottom roller. The larger wrapping arc (a, Fig. 9) results in an additional fiber control zone. However, it can also result in a wider spread of the fiber ribbon.

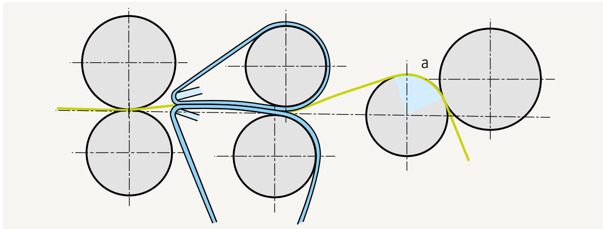


Fig. 9 – The INA drafting system

3.3.3. The top rollers
3.3.3.1. Types

Spinning mills operate with two groups of top rollers (pressure rollers):
- rollers mounted on bearings at both ends on draw frames and in the combing room and
- twin rollers (also known as compensating rollers) on roving frames and ring spinning machines.

Compensating rollers are supported by the pressure arm in the center. They can rock slightly relative to the axis of the bottom roller. They are available in two versions:
- fixed rollers, with the two pressure bodies (1, Fig. 10) at left and right forming a rigid unit which can only be rotated together and
- loose rollers, with the two pressure bodies separately mounted and able to rotate independently of each other.

A distinction is also made according to whether the roller bodies can be removed from the shaft (removable shell), or are permanently attached to the shaft (non-removable shell). The roller bodies are mounted on single-row or double-row ball bearings.

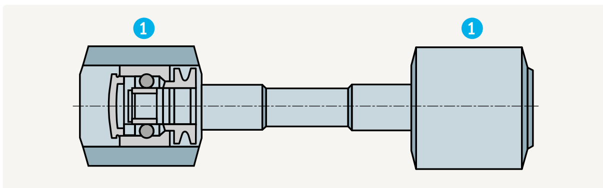


Fig. 10 – Pressure roller

3.3.3.2. Covers

The pressure roller covers are made of synthetic rubber. The cover in the form of a short tube is fitted onto the bearing sleeve with a certain degree of pretension and glued in position, an operation that has to be performed with the greatest care. There are different ranges of hardness:
- soft: 60° - 70° Shore
- medium hard: 70° - 90° Shore
- hard: over 90° Shore

Covers of less than 60° Shore are not usually of any use, since they are unable to recover from the deformation resulting from the contact pressure during a revolution of the roller. Soft covers have a larger contact surface, and therefore enclose the fiber bundle more fully, thus providing more effective guidance. However, they also wear rather more quickly and have a greater tendency to form laps due to the fulling effect. Harder covers are therefore used wherever possible. This is the case, for example, at the draw frame infeed. Here a compact, unified fiber bundle with a slight twist, requiring no increased guidance, is fed in. However, increased control of this nature is an advantage at the delivery end, where only few fibers remain in the bundle and these have a tendency to drift apart. Covers with approx. 80° - 85° Shore are therefore usually used on the back rollers and 63° - 67° Shore on the front rollers. Harder covers are also chosen at the front, i.e. at the delivery end, for coarser yarns and manmade fiber yarns due to wear (also due to the higher tendency to lap formation in the case of manmade fibers). Since the covers wear, they have to be ground on special grinding machines from time to time (after some 3 000 - 4 500 operating hours). The reduction in diameter should be some 0.2 mm, and the covers should never be ground to a total thickness of less than 3.5 mm.

3.3.4. Pressure roller loading
3.3.4.1. Loading options

Three types of pressure roller loading are used on ring spinning machines:

- spring loading (most manufacturers);
- pneumatic loading (Rieter on all machines for some decades, and recently also Texparts);
- magnetic loading (previously by Saco Lowell).

Loading supports are required for mounting the top rollers using the first two types. These bearing arms are attached to continuous shafts or tubes mounted behind the rollers. They can be opened and closed by means of levers in order to reduce and increase the loading, respectively.

3.3.4.2. Spring-loaded pressure arm (Texparts PK 225, for example)

Each compensating roller is seated in a bearing slide (1, 2, 3); these are infinitely adjustable relative to each other. A spring (4, 5, 6) – sometimes two on the front roller – presses the top roller against the bottom roller. In the case of SKF the loading pressure can simply be adjusted in three stages by means of a tool. Colored marks indicated the set loading stage.

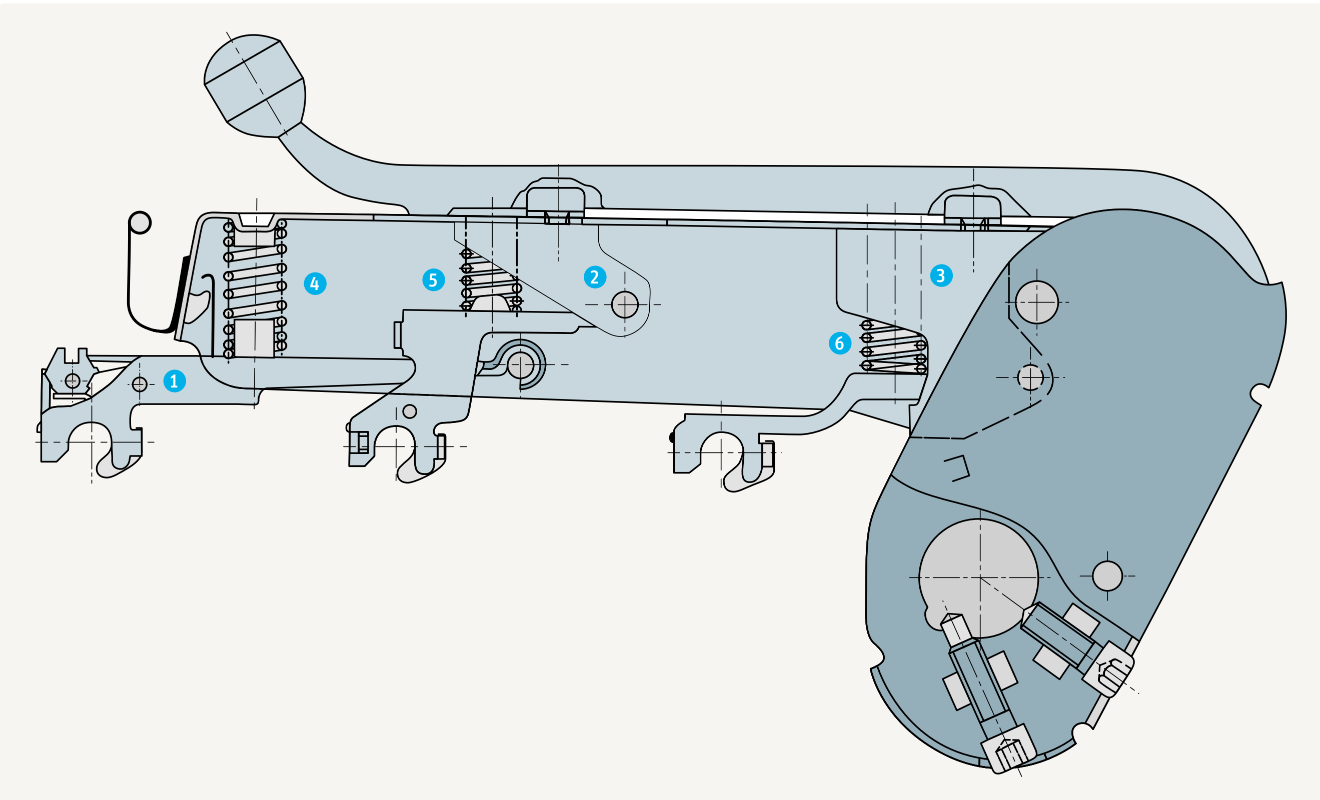


Fig. 11 – SKF PK 225 rocking support

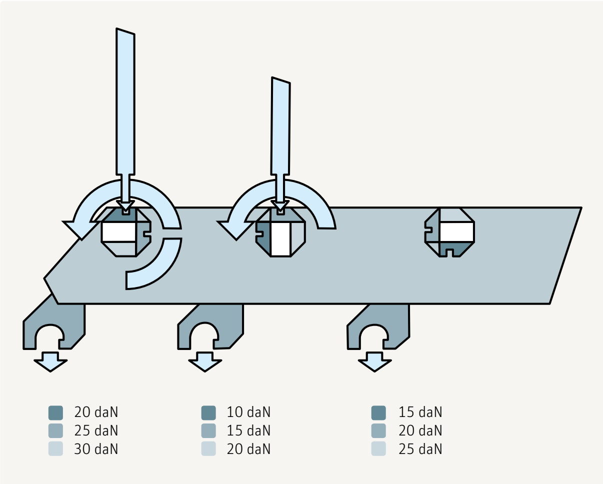


Fig. 12 – Changing the loading on the PK 225 rocking support

3.3.4.3. Pressure arm with pneumatic loading (Rieter FS 160 P 3.1, for example)

The loading support is stamped from steel sheet and is mounted on a continuous hexagonal section tube behind the rollers. The tube contains the compressed air hose connected to a central compressor unit. Three top roller holders mounted on two bearing slides are accommodated in the loading support itself. The two bearing slides form a double lever system. Depending on where a pin is inserted in one of the three holes as the pivot at „m“, the total pressure coming from the compressed air hose and acting on the entire pressure arm via a cam is applied more strongly to the back roller or the two front rollers. Pressure can also be distributed differently between the two front rollers via a second pin/hole system in the bearing slide of these two rollers at „n“.

The total pressure on the top rollers is changed by simply adjusting the pressure in the compressed air hose via a reducing valve at the end of the machine, and distribution to the individual rollers via the system of levers already referred to. The main advantages of pneumatic loading are:

- simple and very rapid, centralized changes in pressure;
- simple and rapid pressure reduction to a minimum in the event of machine stoppages, so that the roller covers are not deformed during prolonged interruptions to operations.

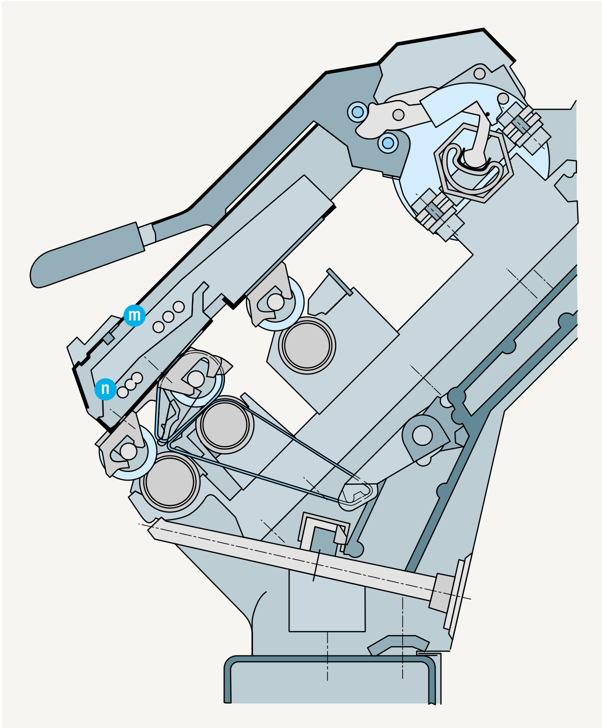


Fig. 13 – Pneumatic loading by Rieter

3.3.5. Fiber guidance devices

3.3.5.1. Options on the ring spinning machine

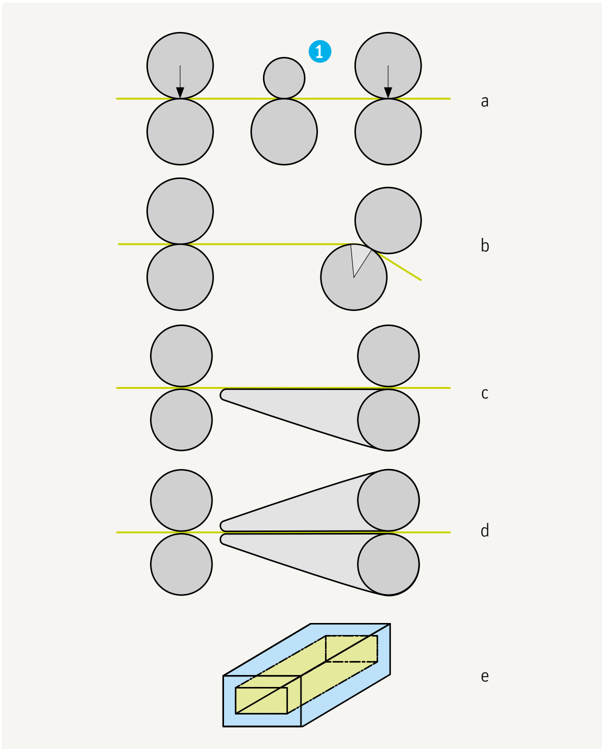


Fig. 14 – Fiber guidance options

The fiber bundle in the main drafting zone consists of only relatively few fibers. There is virtually no friction zone, and fiber guidance by rollers alone is inadequate. The shorter fibers in particular also have to be controlled in terms of speed within the drafting zone. Special fiber guidance devices are therefore required in order to perform satisfactory drafting. The following guidance options can be envisaged for a ring spinning drafting system (Fig. 14):

- line guidance:
  A small aluminum or wooden roller (1), the so-called dummy roller, presses with its low dead weight against the bottom roller. This device is no longer used in modern drafting systems (a).
- surface guidance: (two-dimensional)
  This can take place in the form of deflection around rollers (b), single aprons (c) or double aprons (d). New ring spinning machine drafting systems are equipped with double aprons, while INA also employs version (b) at the feed rollers.
- spatial guidance: (three-dimensional, e) (fiber channel)
  Only this device can provide optimum fiber control and thus fewer irregularities. However, it is difficult to work with, since the size of the channel, for example, should always be adjusted to the bulk of the material. Nevertheless, this principle has already been implemented in the Ambler drafting system of the English worsted spinning process. Spatial guidance would be ideal with moving surfaces rather than the stationary surfaces illustrated in the drawing.

3.3.5.2. Double apron drafting system with long bottom apron

In the double apron drafting system the fiber guidance unit consists of two aprons rotating with the middle rollers. The top apron must be pressed against the bottom apron with controlled force in order to provide guidance. For this purpose there must be a gap between the two aprons at the apron delivery end (tensor gap) that is precisely adjusted to the fiber volume. This gap can be adjusted by using different spacer plates, shoes, etc.
The top aprons, which are often plastic aprons, are always short. However, the bottom aprons can be as short as the top aprons (Fig. 16) or quite a bit longer and guided accordingly around deflecting elements (Fig. 15). The advantage of long bottom aprons over short aprons is that they are easy to replace in the event of damage. They are also less inclined to become clogged with fiber fly.

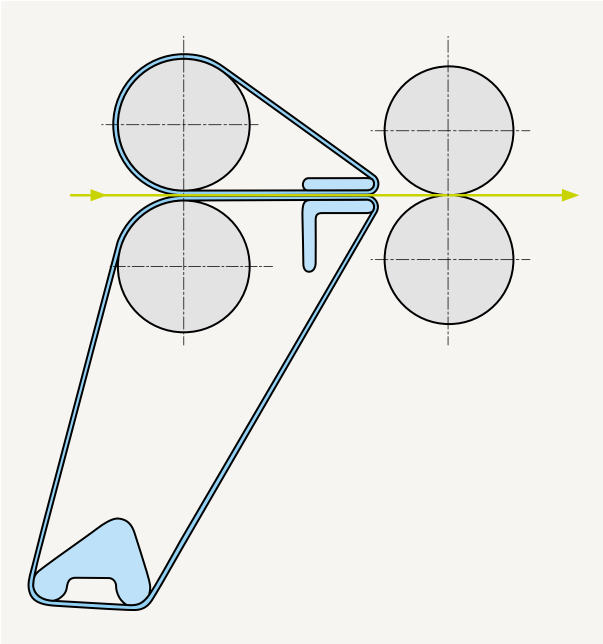


Fig. 15 – Long bottom apron

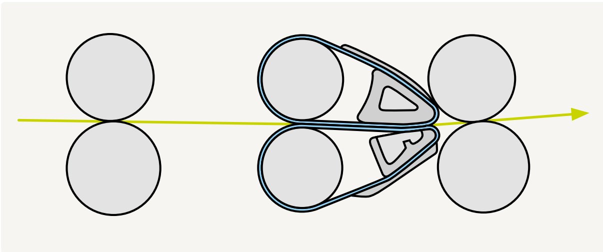


Fig. 16 – Short bottom apron

3.3.5.3. Double apron drafting system with short bottom apron

Although the short apron arrangement is almost as old as that with the long apron, it is not used so often. The drawback of short aprons is that they are more difficult to replace in the event of damage. They can also be more inclined to become clogged with fiber fly if holders are used, and then they run out of true. However, they also have distinct advantages:

- less design effort, i.e. cheaper;
- structural components under the drafting system, such as deflectors, cleaning devices and guides, can be dispensed with, and accessibility under the cylinders is improved;
- they can be placed closer to the front rollers, which improves fiber control.

3.4. The spindle

3.4.1. The threadline

The yarn produced in the drafting system by twisting is fed directly over the spindle by means of thread guide eyelet (1). Before it is taken up on the spindle it passes over a second thread guide unit, balloon checking ring (2). Take-up on spindle (4) itself takes place as a result of the interaction between the speed of the ring traveler rotating on ring (3) and that of the spindle. The spindle is the third most important machine component after the drafting system and the ring/traveler combination. The spindle theoretically permits speeds up to 25 000 rpm.
However, this speed cannot be exploited to the full due to the limitations imposed by the traveler speed and/or the yarn tension in the spinning triangle zone.

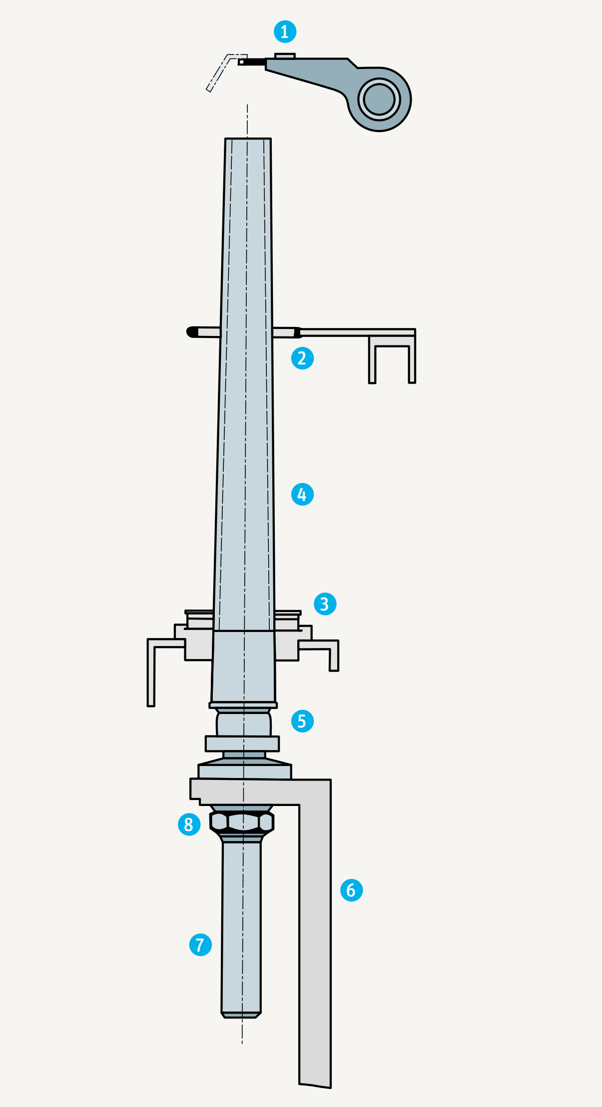


Fig. 17 – Thread guide eyelet (1), balloon checking ring (2), spindle (4/7) and ring (3)

3.4.2. Spindle structure

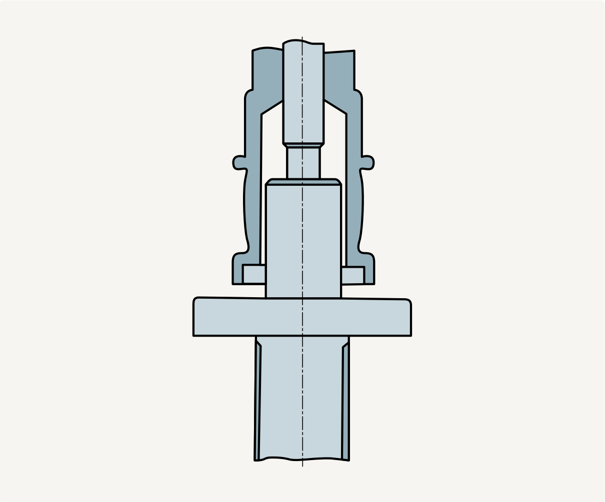


Fig. 18 – Cap wharve

The spindle consists of two distinctly separate parts, spindle center shaft (4) and enclosed bearing housing (7). Nowadays the center shaft is made from an aluminum alloy and is slightly tapered (e.g. 1:64). It has a tube coupling at the top (also at the bottom on large spindles) to ensure that the tube is firmly seated on the shaft.

The bottom end of the shaft takes the form of a wharve (5). This is a cap wharve, i.e. it is hollow and can therefore be fitted over the spindle collar accommodated in the bearing housing (Fig. 18). The tensile forces generated by the drive belt therefore act directly on the bearing, which favorably influences the smooth running of the spindle. However, the size of the wharve is important as well as its shape. If its diameter can be kept small, equally high spindle speeds can be achieved at lower drive speeds (cylinder/belts). This results in lower energy consumption. However, in order to ensure that the drive belt rotates the spindle slip-free, the diameter of the wharve must also not be too small. Wharve diameters of 19 to 22 mm are customary at present.
Bearing section (7) is bolted firmly to ring rail (6) by nut (8) (Fig. 17).

3.4.3. The spindle bearing

The design of a modern spindle bearing is briefly explained here on the basis of the Texparts CS1 spindle (Fig. 19). The spindle bearing consists of 2 parts, a spindle collar bearing (1) and a spindle step bearing (3). Both parts are connected via housing (7). The spindle collar comprises

a precision roller bearing. The spindle step, designed as a friction bearing (conical bearing), is responsible for the elastic centering and cushioning of the spindle center shaft. Two centering and cushioning elements (6) control the bearing shaft (2). An oil-filled spiral (10) mounted symmetrically with the spindle step ensures optimum cushioning. Spindle step (3) also absorbs all vertical forces acting on the spindle.
The spindle collar can be a friction bearing or a roller bearing. The noise level can be reduced considerably by using friction bearings, but energy consumption is somewhat higher. Most spindles are therefore equipped with roller bearings. The spindle collar is rigidly friction-set in the bearing housing in standard spindles. Bearing vibration is therefore transmitted to the spindle frame without damping. This results in high noise levels at higher speeds. For speeds over 18 000 rpm, spindles are therefore mostly used in which not only the spindle step, but also the spindle collar is attached flexibly to the bearing housing (e.g. Novibra HP-S 68). These spindles are more expensive, but permit higher speeds and reduce noise levels in ring spinning machines by some 10 dB (a) compared with standard spindles.

Spindle step (3) is always a friction bearing and flexible, i.e. it can tilt sideways to a small extent. The spindle is therefore able to center itself, which enables it to operate in hypercritical ranges. This results in a significant reduction in bearing forces. High-performance spindles are inconceivable without damping devices (10). Various systems are used, such as damping spirals, damping tubes or damping oil around a steel tube.

If damping spirals are used, spiral spring (a) is compressed at one side when the spindle is deflected to side (b) (Fig. 20). The oil therefore flows from this side to the other side, where the gaps become wider (c). The resistance the oil has to overcome in the process damps the vibration in the spindle step and ultimately in the shaft.

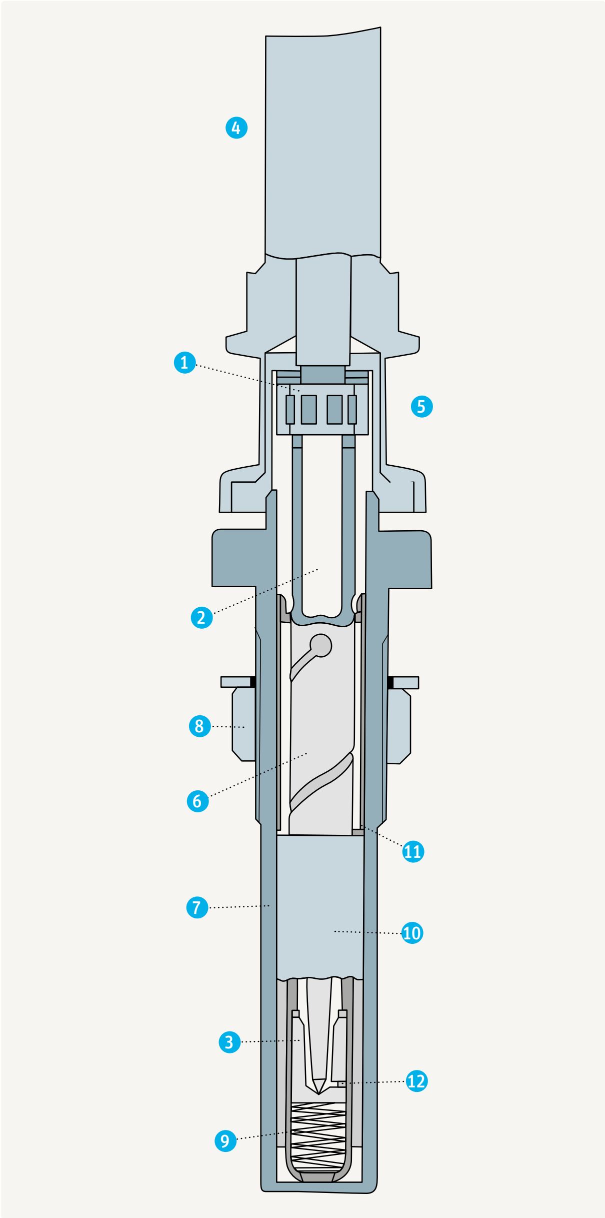


Fig. 19 – Vibration absorber (10) in a spindle bearing

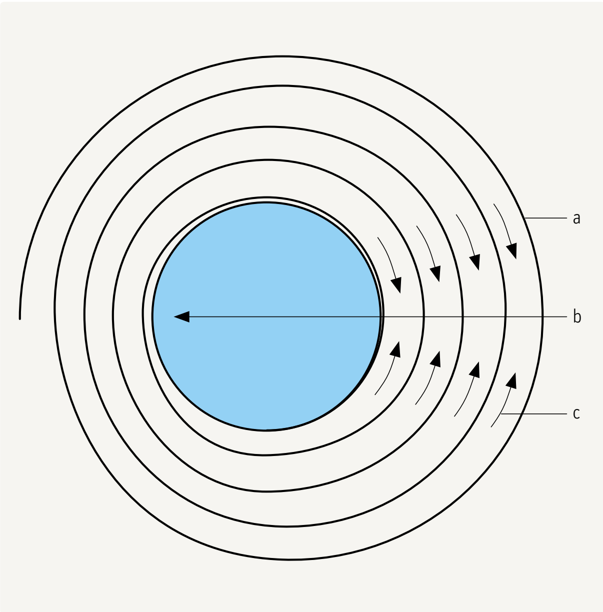


Fig. 20 – Spindle damping function: a, spiral spring; b, spindle blade; c, oil flow

The cavity between the spindle blade and the bearing housing is largely filled with lubricating oil. Since the oil is used up, it has to be replenished from time to time. This is necessary after about 10 000 - 25 000 operating hours.

3.4.4. Influence of the spindle on the spinning process

Spindles (and the spindle drive) have a considerable influence on the machine‘s energy consumption and noise level. However, the running behavior of the spindle, especially balancing errors and eccentricity relative to the ring, also have an impact on yarn quality and, of course, on ends down frequency. Badly running spindles have an adverse impact on almost all yarn parameters. Spinning mills must therefore always ensure the best possible centering of rings and spindles. Since the ring and the spindle are units that are independent of each other and can change position relative to each other during operation, these components must be centered from time to time. This used to be done by moving the spindle relative to the ring, but now usually involves adjusting the ring. Mechanical or electronic devices are used for centering.

3.4.5. The spindle drive
3.4.5.1. Types

A basic distinction is made between three groups of spindle drive:
- tape drive
- tangential belt drive and
- direct drive.

Tape drive is in turn sub-divided into:
- individual spindle drive and
- group drive

and direct drive into:
- mechanical and
- motorized direct drive.

Mechanical direct drive is no longer used today, and the motorized version, i.e. featuring individual spindle motors, has been introduced on an experimental basis by the SKF company. Only group drive in the form of 4-spindle tape drive or tangential belt drive are usually used in short staple spinning. Compared with tangential belt drive, 4-spindle tape drive has the advantage of operating with rather lower noise levels and energy consumption, although belts are easier to replace. The advantages of tangential belt drive are: elimination of drive elements under the machine, less air disturbance under the machine and perhaps rather less maintenance effort.

3.4.5.2. 4-spindle tape drive

In the 4-spindle tape drive a tape drives two spindles on one side of the machine and two further spindles on the other side of the machine. When changing from one side to the other the tape passes around a drive cylinder or drive pulley (1). 1 - 2 tension rollers (2) ensure good, uniform tensioning of the tape.

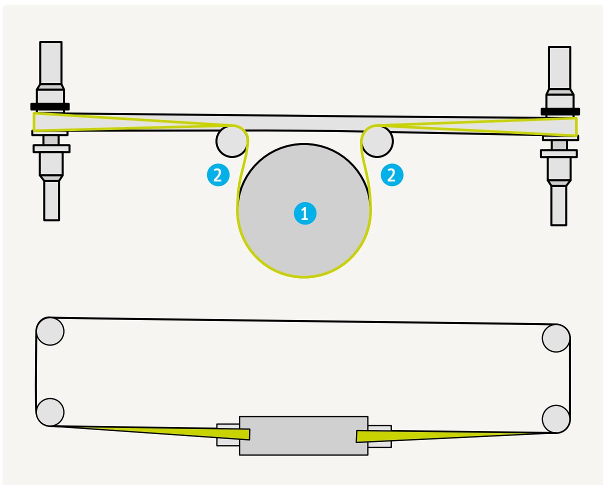


Fig. 21 – 4-spindle tape drive

3.4.5.3. Tangential belt drive

In the tangential belt drive a belt coming from the suspended drive motor passes along the back of all the spindles. A large number of pressure rollers ensure that the belt is pressed uniformly against all the spindles. A fundamental distinction is made between three basic forms: single-belt, double-belt and group drive.

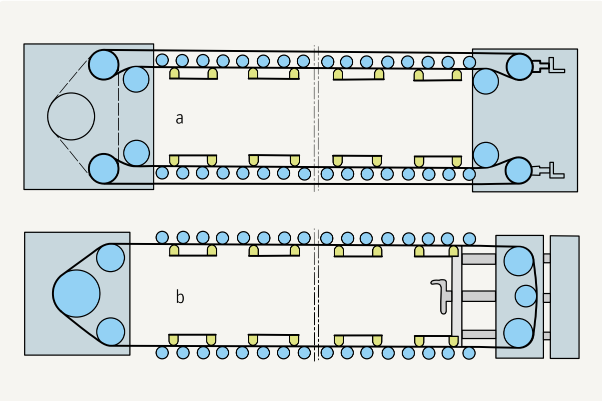


Fig. 22 – Tangential belt drive

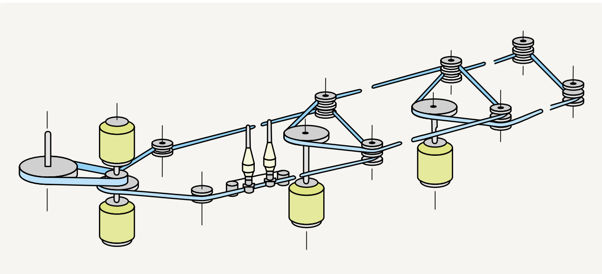


Fig. 23 – Group drive (new from SKF Almanac)

In the first case, an endless belt drives the spindles on both sides (Fig. 22, b), in the other system there are two belts, one of which drives the spindles on one side, and the second those on the other side (Fig. 22, a). The double-belt system results in more uniform spindle speeds. With the single-belt system, differences can arise due to the widely differing tension in the belts, especially on long machines. Group drive is being used increasingly nowadays instead of the single or double-belt version (Fig. 23). In this system a tangential belt drives 50 spindles on each side of the machine, for example, i.e. 10 group drives with 10 motors operating synchronously are needed for a machine with 1 000 spindles. Speed synchronization must be guaranteed. In another group drive system only 1 tangential belt is used. However, this belt is then driven by several motors operating synchronously along the length of the machine.

3.5. The thread guide devices
3.5.1. The thread guide

Fitted immediately over the spindle, the thread guide has to guide the yarn centrally over the center axis of the spindle. The thread guide consists of wire eyelet (o) and thread board (k). The thread guide eyelet is mounted adjustably in the thread board to enable it to be centered. The latter is itself fitted on a continuous thread guide rail (r). The rail can be raised and lowered together with the thread guides. While cops are being wound it performs the same movements as the ring rail, but with a smaller traverse height:

- continuous raising and lowering during layering and
- continuous lift by small amounts as switching traverse.

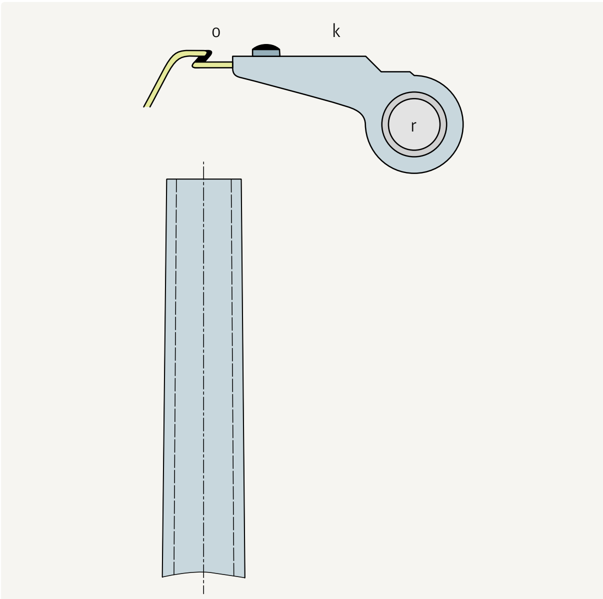


Fig. 24 – Thread board (k) and thread guide eyelet (o)

As shown in Fig. 25, this prevents the differences in balloon height between the individual ring rail positions from becoming too large. Otherwise excessive differences in yarn tension would arise, with correspondingly negative effects on ends down frequency and yarn properties. Thread guides must be centered from time to time by means of a pointer (s) fitted on the spindle. Since the thread passes through the inside edge rather than the center of eyelet (o), the tip of the centering pointer must point to the inside edge of the eyelet (Fig. 26).

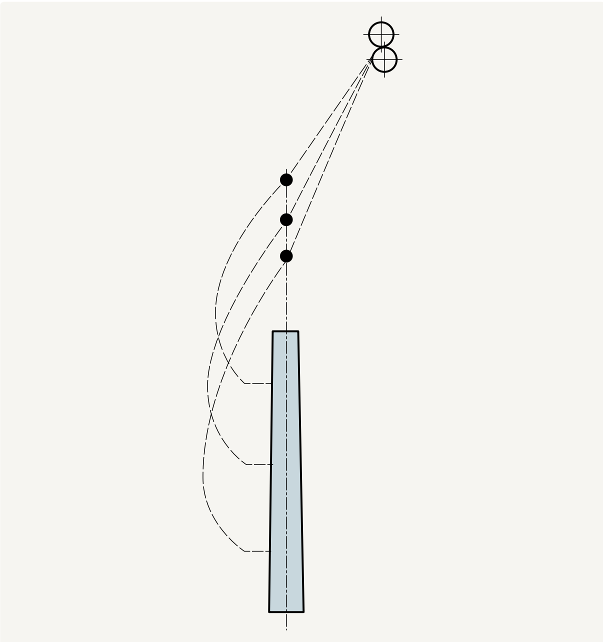


Fig. 25 – Raising the thread guide eyelet as the balloon becomes smaller

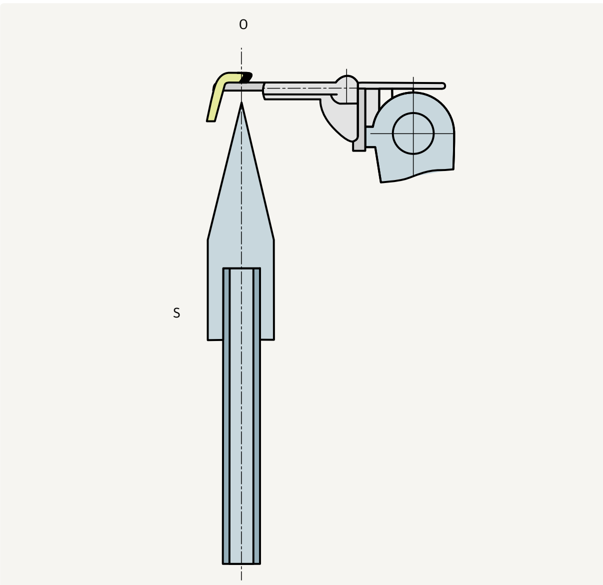


Fig. 26 – Centering the thread guide eyelet

3.5.2. The balloon checking ring (BER) (antiballooning device)

Relatively high spindles are generally used nowadays. The distance between the ring and the thread guide eyelet, and therefore the balloon, is therefore correspondingly large, especially during winding on the bottom end of the tube. When dragging the ring traveler with it, the yarn in the balloon therefore assumes a distinctly curved shape. The balloon becomes unstable and may collapse. In order to prevent this „necking“ (transition from a single to a multiple balloon), the balloon is restricted in the middle by the balloon checking ring in such a way that two smaller balloons are formed which are in themselves stable. Balloon checking rings permit operation at higher speeds, but can result in:

- napping of the thread,
- severe fiber abrasion (formation of fly) and
- formation of melt points on manmade fibers

as the thread rubs against them.

Close attention must be paid to the last of these. In the same way as the thread guides, the balloon checking rings also perform the traversing motions of the ring rail in smaller amounts.

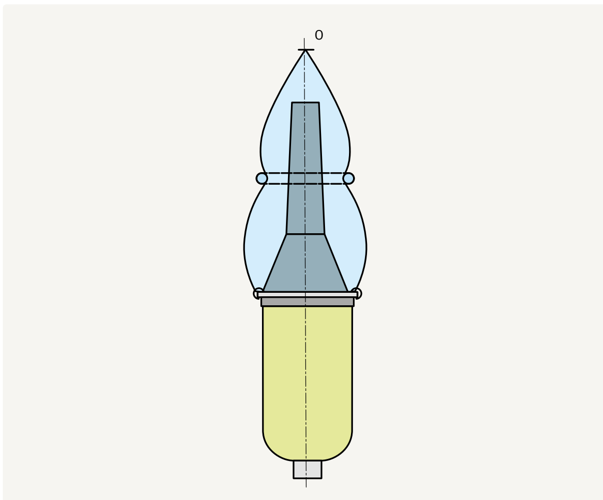


Fig. 27 – Balloon checking ring

3.5.3. The separators

Most ends down occur in the spinning triangle, since that is where very high forces act on a fiber bundle that is not yet fully integrated. If a break occurs, the yarn end that has now become free must be pulled to the cop and wound onto it. On its way there the thread whirls around the spindle. In the absence of a protective device the yarn would be flung into the neighboring balloon and that yarn would also be broken. This would be repeated continuously, resulting in serial ends down. In order to prevent this, aluminum or plastic separator plates are arranged between the individual spindles (Fig. 28).

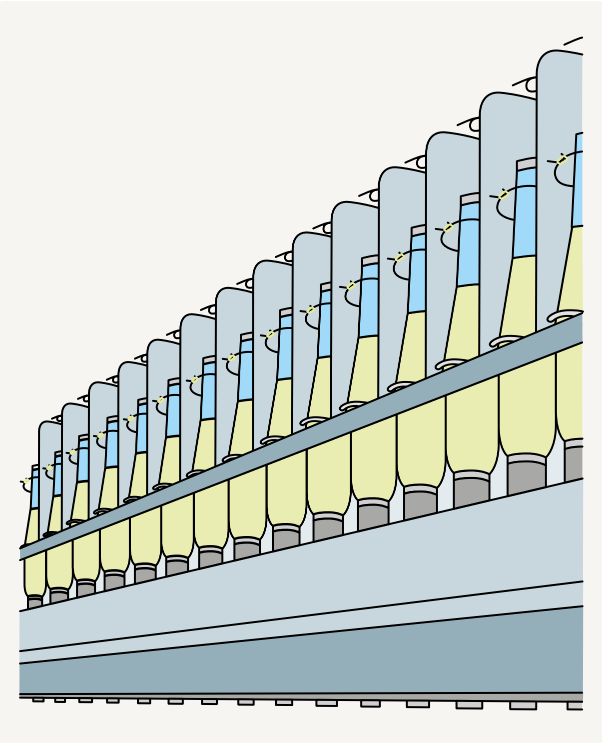


Fig. 28 – Separators

3.6. The ring
3.6.1. The importance of ring and traveler

The ring traveler is in most cases responsible for the limitation of the ring spinning machine‘s productivity, depending on the interaction of ring, traveler and yarn. It is therefore important for the specialist to be aware of the influencing factors and to act in accordance with this knowledge. Optimum running conditions depend on:
- ring and traveler material
- surface finish of the components
- the shape of both components
- coordination of the shapes
- wear resistance
- smooth running
- running in procedure
- fiber lubrication.

This list shows that the manufacturers of these machine components can exercise the greatest influence, and the spinning specialist can only ensure good conditions by choosing and handling them correctly in the spinning mill.

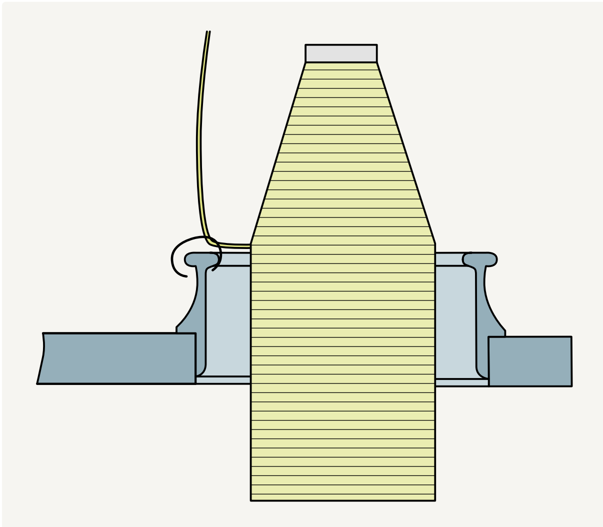


Fig. 29 – Ring and traveler

3.6.2. The ring shape
3.6.2.1. Basic shapes

A distinction is made between:
- unlubricated rings and
- lubricated rings (in carded yarn and worsted spinning).

The standard rings used in short staple spinning, the unlubricated rings, are also divided into:
- T-flange rings and
- inclined-flange rings.

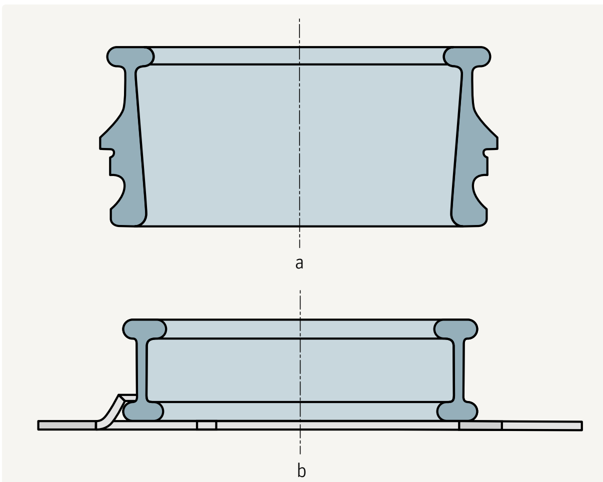


Fig. 30 – Single-sided and two-sided ring

3.6.2.2. T-flange rings

T-flange rings are either single-sided (Fig. 30, a) or two-sided (Fig. 30, b). Single-sided rings have to be replaced by new ones when they wear out, while two-sided rings can then be reversed and used on the other side. However, it often transpired that the underside, which had been unused to that point and served as a mounting, had become unserviceable due to corrosion, etc. These rings are therefore now hardly used. Two dimensions are especially important in short staple spinning rings, namely inside diameter D and flange F (Fig. 31).
Rings are available with inside diameters D in the 36 to 57 mm range.

Flange sizes are standardized:

Flange No.	1	(1.5)	2
Flange width (F, mm)	3.2	(3.7)	4.1

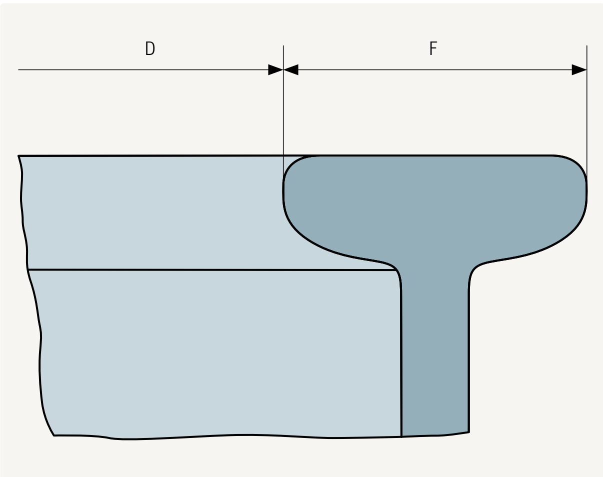


Fig. 31 – Ring flange

3.6.2.3. The „anti-wedge“ ring

This was the first high-performance ring. It is still on sale. Compared with the previously customary ring shape, it features a flange with a flared inside surface and is flattened off considerably on top. This change in shape enabled a ring traveler with a low center of gravity and precisely adjusted arc (elliptical traveler) to be used and thus also permitted operation at higher speeds. Anti-wedge rings and elliptical travelers belong together and should only be used in combination. Since the space for the yarn passage is limited, this combination can only be used for fine and medium count yarns.

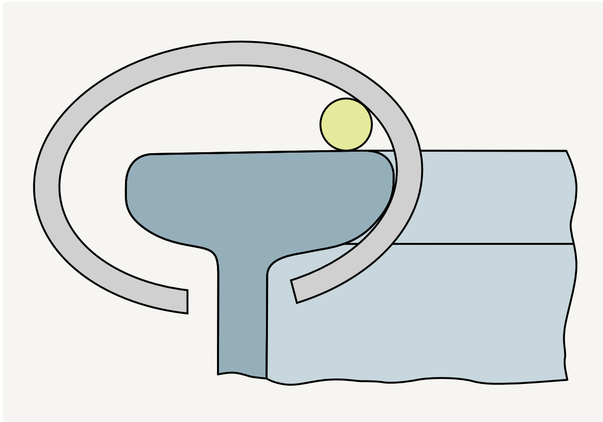


Fig. 32 – Anti-wedge ring

3.6.2.4. The „cropped ring“ (standard ring)

In the case of the cropped ring the arc was flattened on top compared with the rings that were customary until then. This resulted in a large space for yarn passage, so that the arc of the ring traveler could also be flattened off (oval traveler/flat traveler) and the center of gravity lowered. Its advantage over the anti-wedge ring is that the space for yarn passage is rather larger and all customary ring travelers with the exception of the elliptical traveler can be mounted on it. This is the most widely used ring shape nowadays and is supplied by all well-known companies, such as Bräcker, Reiners & Fürst, etc.

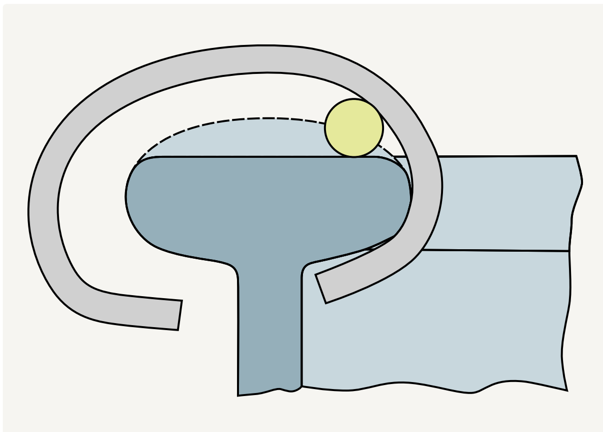


Fig. 33 – Cropped ring

3.6.2.5. Inclined-flange rings

This type of ring was invented in Russia and marketed as the „SU ring“. For various reasons, the success of this ring was very limited. Rieter took up this very interesting design

and developed it to perfection in the late nineteen-eighties. The corresponding ring was launched on the market under the ORBIT brand name in 1991.
The outstanding advantage of inclined-flange rings, and of the ORBIT system in particular, is the much larger contact area between ring and traveler compared to T-flange rings (Fig. 34, left). This considerably reduces the pressure between ring and traveler and thus improves heat dissipation from the contact area (The forces acting on the traveler in a plane through the spindle axis are shown in Fig. 34, right). These features make ORBIT rings and the corresponding travelers a high-performance system. In comparison to T-flange rings, ORBIT rings enable traveler speeds to be increased by up to 15 %.

3.6.3. The ring material

The ring should be tough on the inside and hard on the outside. Very close attention should be paid to the running surface in particular in this respect. Uniformly high hardness of the boundary layer of about 800 - 850 HV is required. A lower hardness (650 - 700 HV) should be chosen for the traveler, so that the traveler, which is less expensive and easier to replace, wears rather than the ring. Surface smoothness is also important. It should be high, but not too high, otherwise a lubricating film cannot form.

The following materials are used:
- case hardening steel in some cases
- nitride steel
- ball bearing steel; this is currently the customary ring material.

However, modern rings usually feature a surface coating. The object of such coatings is:
- to reduce friction,
- to reduce wear,
- to prevent corrosion and
- to simplify running-in the ring.

Coatings used include:
- oxides
- nitriding
- carbonitriding
- hard chrome
- nickel (in some cases containing hard particles)
- ceramics.

3.6.4. Attachment of the rings

The rings are attached to the rising and falling ring rail. Previously, they were fitted rigidly in the ring rail, but they now have to be movable, since the spindles are no longer

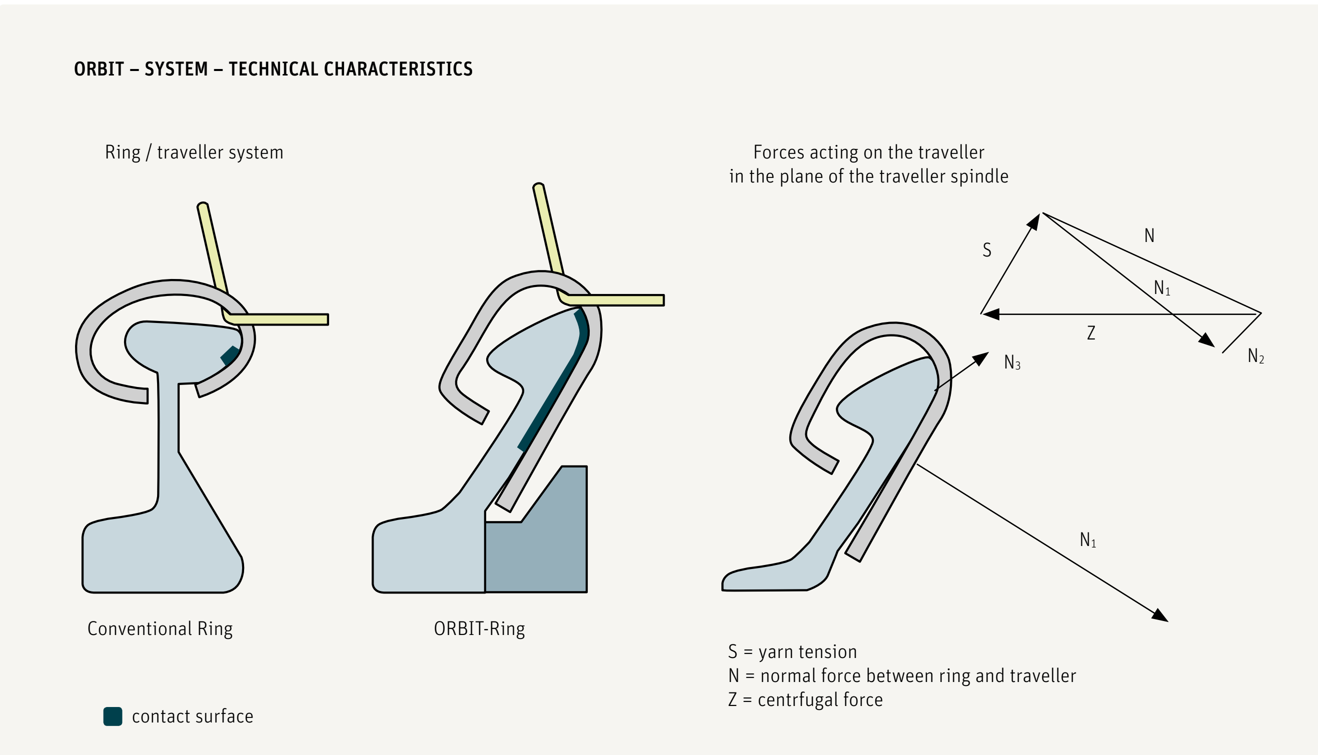


Fig. 34 – Rieter Orbit ring

centered on the rings; the rings are now centered on the fixed spindles, which involves much less effort. The rings on modern machines are therefore bolted adjustably on the ring rail with appropriate adapters.

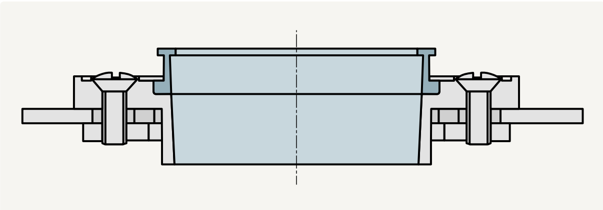


Fig. 35 – Attachment of the rings

3.6.5. The demands imposed on the ring when operating on the machine

These are the requirements for a good ring:
- the best possible raw material as starting material
- good, but not excessive surface smoothness
- flat surface
- precise ring roundness
- good, uniform surface hardness, higher than that of the traveler
- perfectly run-in rings (optimum running-in conditions)
- long service life
- correct ratio of ring diameter to tube diameter (2:1 to 2.2:1)
- exact horizontal position
- exactly centered relative to the spindle.

3.6.6. Fiber lubrication on the ring

It used to be assumed that the interaction of ring and traveler involved purely metal/metal friction. Fortunately for spinning mill operators, this is not the case, since metal/metal friction would probably limit traveler speed to about 28 - 30 m/s. In fact, however, the traveler moves on a lubricant film it has created itself, consisting primarily of fiber abrasion waste. If fiber particles are caught between the ring and the traveler at high speeds and correspondingly high centrifugal forces, they are partially crushed by the traveler. It compresses them as small, colorlessly translucent lamina several μm thick into a solid running surface. These lamina adhere very differently to the ring and within the lubricant film, and are therefore repeatedly stripped off, but also renewed again.

The position, form and structure of the lubricant film depends on many factors, such as yarn count, yarn structure, yarn raw material, traveler mass, traveler speed, arc height, etc. For example, only little fiber lubrication can be expected with yarns finer than 7.5 tex (Ne 80) due to the low traveler mass and thus low centrifugal force.
In this case maximum traveler speed is therefore lower than for medium-count yarns. Travelers reach speeds of up to 40 m/s and more with modern ring/traveler combinations when fiber lubrication is functioning effectively.

3.6.7. Running-in new rings

If worn rings are replaced by new ones, these lack a lubricant film. Purely metal/metal friction therefore prevails for a certain length of time. This is a very critical phase, since the rings can very quickly be damaged by scoring and pick-up. Ring manufacturers have therefore specified precise rules for running-in, adapted to the given type of ring, for the running-in phase during which the surface of the ring has to be smoothed and passivated (oxidized) and coated with a lubricant film.

These can include, for instance:
- Do not degrease new rings, simply wipe them with a dry cloth.
- Select the correct ring traveler, but reduce spindle speeds by 15 - 20 % (or normal spindle speeds and ring travelers 1 - 2 numbers lighter).
- First traveler change after 15 min.
- Second traveler change after 30 min.
- Third traveler change after 1 - 1 1/2 h.
- Fourth traveler change after 1st doffing.
- Traveler change after 2nd + 3rd doffing.
- Traveler change after 5th + 8th doffing.

Spindle speed can be increased in stages in the meantime. With yarns finer than 7.5 tex (Ne 80) running-in is an even more delicate and protracted procedure. In this case speeds should be reduced by 20 - 30 % and the rings smeared from time to time with oil-soaked felt.

3.6.8. Follower rings

The problem that limits the productivity of ring spinning machines is the generation of heat in the traveler. There are two possibilities for avoiding this:
- by preventing heat generation or
- by rapid dissipation of the heat generated.

Since increasing performance via heat dissipation is only possible in very small steps, attempts are repeatedly made to prevent heat generation. However, this is only possible to a large degree if the relative speed of the ring and the traveler can be reduced to almost zero or even zero, i.e. the ring must also rotate. The result is the follower ring.

In this design the rings are mounted on ball bearings or rotate as rotors in an air bearing. These rings usually follow the traveler. However, at start-up only the traveler rotates initially until the centrifugal force and thus the contact pressure are sufficient to start the ring rotating. The ideas on which this system are based are convincing, but its realization is difficult. The following problems arise in particular:
- the machine is considerably more expensive
- larger gauge
- possibly controllable spinning start-up and spinning-out speed
- possible braking device
- possible change in spinning geometry
- very delicate and complicated bearing.

In addition, rotating rings often permit only an inadequate increase in spindle speed in practice, since other limits of the ring spinning machine (yarn tension, specific energy consumption) are very quickly reached. Since the effort invested is often greater than the potential benefit, rotating rings have not become established in practice today.

3.7. The ring traveler

(See also The Rieter Manual of Spinning,
Volume 1 – Technology of Short-staple Spinning)

3.7.1. Task and function

The traveler
- imparts twist to the yarn and
- is responsible for winding the yarn onto the cop.

However, a second device – the spindle – is required for winding. In this process the take-up length always corresponds to the difference between the peripheral speeds of the two units. This must be equal to the delivery length in the long run. The difference is due to the fact that the traveler speed lags behind the spindle speed, since the traveler does not have its own drive, but is only carried along by the spindle. The yarn tension (yarn tensile force) necessary for a stable balloon is generated by the friction of the traveler on the ring (and partly by the drag of the thread balloon). The traveler is pressed against the ring mainly by the centrifugal force acting on it. This results in the above-mentioned friction between the ring and the traveler. However, this friction caused by the high contact pressure (up to 35 N/mm) also generates considerable heat. This is the root of the ring/traveler problem, since the small mass of the traveler means that it is not possible to dissipate the heat generated in the time available. The result of this is the limitation in traveler speed.

3.7.2. Types

Travelers have to wind up very different yarns:
- coarse/fine
- smooth/rough
- compact/bulky
- strong/weak
- natural fibers/manmade fibers.

It is impossible to spin this diversity of yarns using only one type of traveler; quite a wide range of travelers is required for this purpose. Differences arise from:
- shape
- mass
- raw material
- additional treatment of the material
- wire profile
- thread passage size (arc height).

It is up to the spinning mill operator to make a choice appropriate to his conditions and requirements.

3.7.3. Traveler shape

The shape of the traveler must coincide exactly with that of the ring flange, so that only one contact surface – which should be as large as possible – exists between the two units. The top of the traveler arc should also be as flat as possible in order to keep its center of gravity low and enhance smooth running. Both of these factors have a significant influence on the traveler speed that can be achieved. However, the flat arc shape must still leave sufficient space for thread passage. If this space is too small the thread rubs on the ring, which results in napping of the thread, high production of fiber fly, reduced quality and the formation of melt points in manmade fibers.

The following traveler shapes (basic shapes) are in use in short staple spinning (Fig. 36):
a) C travelers
b) flat or oval travelers
c) elliptical travelers
d) N travelers
e) and the ORBIT travelers shown in Fig. 34.

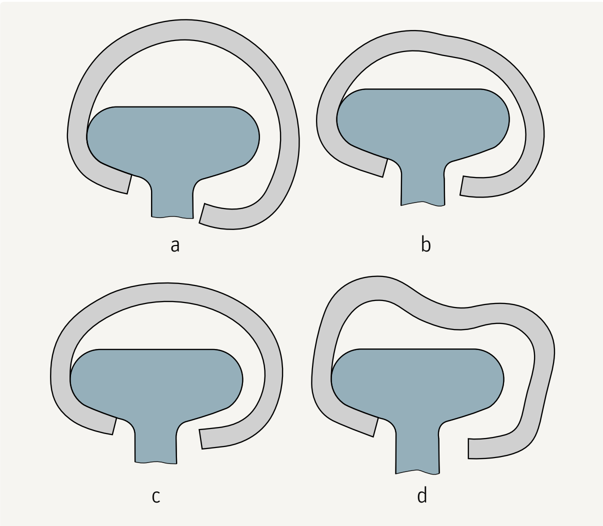


Fig. 36 – Traveler shapes: a, C traveler; b, flat traveler (standard traveler); c, elliptical traveler; d, N traveler

The wire profile also influences running behavior, i.e. through:
- the contact surface on the ring
- smooth running
- heat dissipation
- thread passage space
- and certain yarn properties:
- sloughing resistance
- hairiness.

Fig. 37 shows several profile shapes (Bräcker).

3.7.4. The traveler material

The ring traveler should:
- generate as little heat as possible
- quickly distribute the heat that is nevertheless generated from the site where it occurs (contact surface) to the traveler as a whole
- dissipate the heat quickly to the ring and the air
- be elastic, so that the traveler can be pressed onto the ring without breaking
- display high wear resistance
- have a slightly lower hardness than the ring, since the traveler must wear rather than the ring.

The travelers used in short staple spinning are therefore made almost exclusively of steel. However, pure steel does not ideally fulfill the first three requirements. Traveler manufacturers have therefore been attempting for decades to improve running conditions through surface finishing. The following methods are suitable for this:
- electroplating, in which the traveler is coated with one or more layers of metal, such as nickel and silver, or
- chemical treatment to change surface properties in order to reduce friction and scoring.

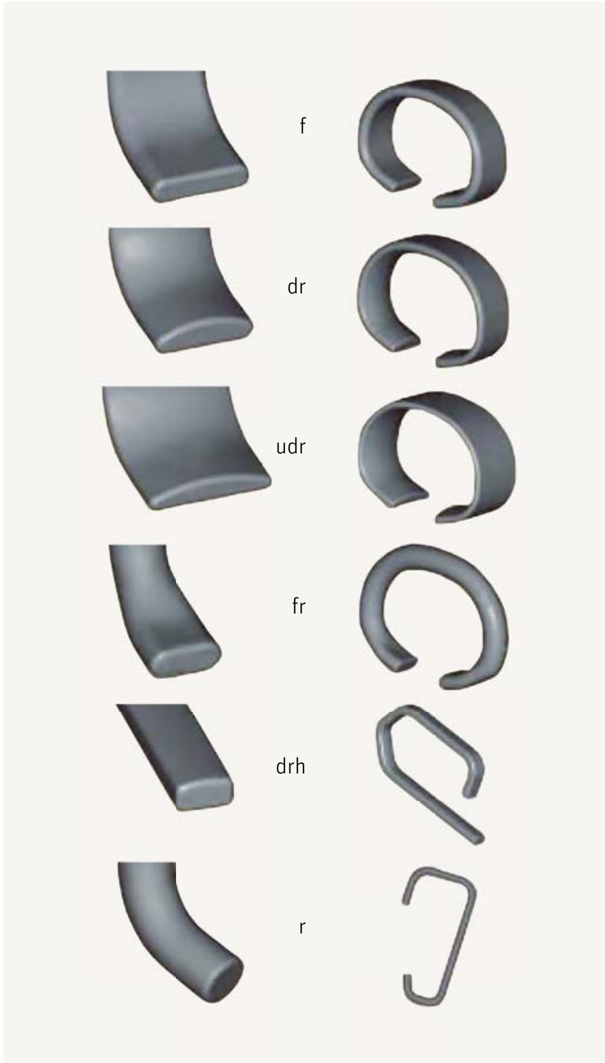


Fig. 37 – Wire profiles for ring travelers

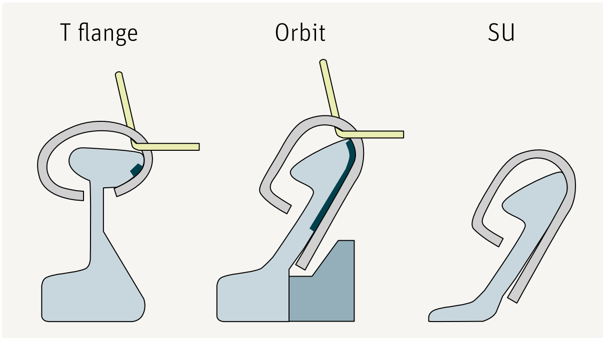
The Bräcker company has developed a new process for introducing certain treatment components into the traveler surface by diffusion and fixing them there (sapphire traveler). This layer reduces heating and increases wear resistance.

3.7.5. Traveler mass

The mass of the traveler determines the degree of friction of the traveler on the ring and thus the yarn tension. If the mass is too low, the balloon becomes too large, the cop too soft and the amount of material taken up on the cop too small. On the other hand, too high a mass results in high thread tension and frequent ends down. The mass of the traveler must therefore be adjusted exactly to the yarn (count, tenacity) and the spindle speed. If there is a choice between two traveler weights, the heavier one is usually preferred, since this results in higher cop weight, smoother running of the traveler and better heat dissipation. The table (Bräcker, Fig. 38) can be of assistance in approximately defining the traveler number (ISO is the new standard here and specifies the mass of 1 000 travelers in grams).

The traveller weights are determined beside the yarn number by the following parameters:

Yarn twist	Knitting	Lighter travellers
Fibre type	Blends, synthetics	1 - 2 number heavier travellers
Spindle speed	Higher RPM	Rather lighter travellers
Spinning geometry		
Small ring diameter	Small balloon	Lighter travellers
Large ring diameter	Large balloon	Heavier travellers



Tex	Nm	Ne	T flange				Orbit		SU			
									PES		PAC and CV	
			Traveller No		ISO		ISO		ISO			
100	10	6	14	18	250	315					250	315
72	14	8	11	14	180	250			250	315	200	280
59	17	10	9	11	140	180			224	280	140	200
50	20	12	6	9	100	140	90	125	200	250	100	160
42	24	14	3	7	80	112	80	112	160	250	90	140
36	27	16	1	4	63	90	71	100	125	200	80	112
30	34	20	2/0	2	50	71	63	90	80	160	63	80
25	40	24	4/0	1	40	63	45	71	80	140	50	71
20	50	30	5/0	2/0	35.5	50	31.5	50	63	112	31.5	63
17	60	36	6/0	3/0	31.5	45	28	40	56	80	31.5	50
15	68	40	7/0	4/0	28	40	25	40	56	71	31.5	45
12	85	50	8/0	6/0	25	35.5	20	31.5	50	63	31.5	40
10	100	60	10/0	7/0	22.4	28	18	25	40	50		
8.5	120	70	11/0	10/0	20	22.4	16	22.4				
7.4	135	80	14/0	11/0	16	20	14	20				
6.6	150	90	16/0	12/0	14	18	14	18				
5.6	180	105	18/0	14/0	12.5	16	12.5	16				
5.3	190	112	19/0	16/0	11.2	14						
4.5	220	132	22/0	19/0	9	11.2						

Fig. 38 – Overview of traveler weights

3.7.6. The traveler clearer

When the yarn, which comprises a large number of more or less firmly integrated, yet relatively short fibers, is fed through the ring traveler, it is inevitable that fibers are detached. Most of them fly away from the traveler, but some also often remain attached to the traveler. These can accumulate and even form clumps. The resulting, excessively high mass of the traveler creates high thread tension and ultimately leads to thread breaks. Fiber strippers, so-called traveler clearers, are mounted near the rings in order to prevent these accumulations of fibers. These should be positioned as close to the traveler as possible, but far enough away not to interfere with the movement of the traveler. Accurate adjustment is very important.

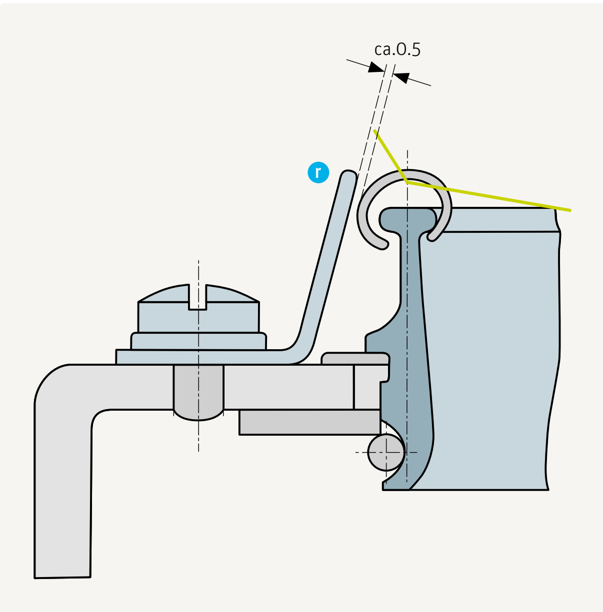


Fig. 39 – Traveler clearer (r)

4. THE MACHINE DRIVE

4.1. The drive problem

Energy accounts for some 10 % of a spinning mill's manufacturing costs (at 20 tex), and the ring spinning installation itself for some 2/3 of this. Even if this does not seem a very high percentage, it is a cost factor that should not be underestimated, especially since there is potential for economies in the energy sector if the correct types of drive and power transmission are chosen. For example, in a ring spinning mill with 25 000 spindles and a total of 7 000 operating hours/year, in which an average of 1 million dollars is spent on energy, savings of 10 % produce some very interesting figures. This power input is used on the ring spinning machine primarily for:

- spindles (with travelers) 65 - 70 %
- drafting systems 25 %
- ring rails 5 - 10 %

However, the technological problem is much more serious than the economic aspect, since differences in yarn tension arise during winding onto the cop. It would be useful to reduce these differences in tension by means of variable spindle speeds. If the ring rail rises during layered winding, i.e. from a large to a small winding diameter, yarn tension increases substantially, e.g. from 25 to 40 cN, and ends down frequency increases accordingly. According to a study by Zinser, most thread breakages occur when the ring rail rises in the upper (not the highest) zone (Fig. 40). In order to maintain thread tension and ends down at constant levels, spindle speeds should be reduced when the ring rail is raised (control of layering speed).
The problem with winding as a whole is similar, since the balloon is very large (Fig. 41, I_1) at the beginning of cop buildup and relatively small at the end (I_2). Yarn tension varies accordingly. Adjustments should also be made here via spindle speed (control of the basic speed). Both speed adjustments were previously made by means of the commutator motor. Nowadays it is mostly only the basic speeds that are changed via variable speed gears, DC motors or frequency-controlled drives.
For this at least a startup step (to prevent startup thread breakages), a base step (for forming the cop base) and a normal step (for winding the cop as a whole) should be available as control options. There is often also a spin-out step for winding the topmost part of the cop, which can be identical to the base step.

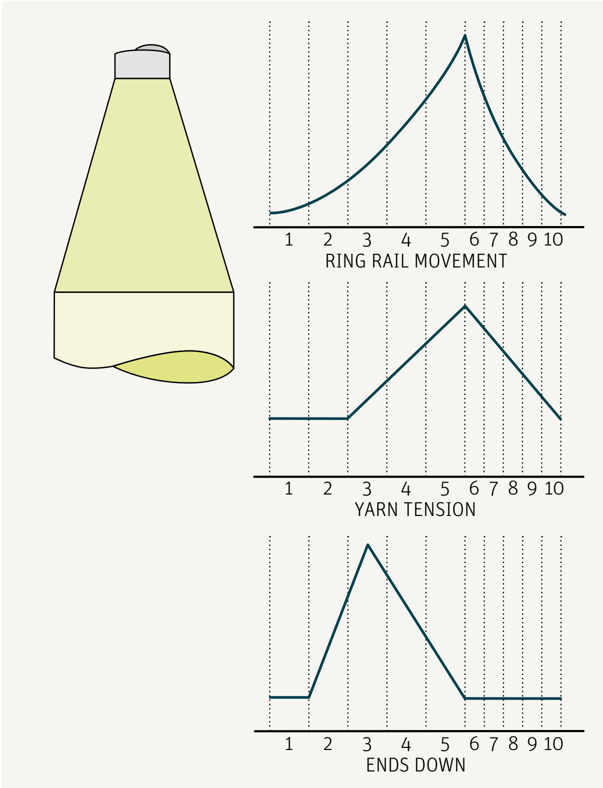


Fig. 40 – Ring rail motion, yarn tension and ends down frequency during a ring rail traverse (Zinser) (simplified)

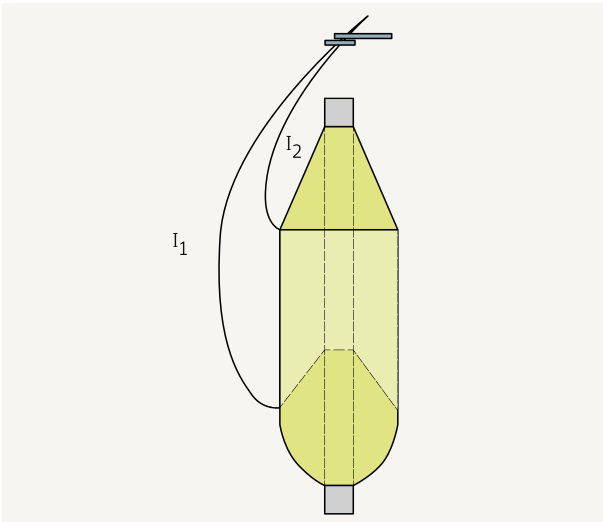


Fig. 41 – Different balloon heights

4.2. Motors used

The following used to be employed in ring spinning mills:
- three-phase squirrel-cage induction motors
- three-phase squirrel-cage induction motors with star-delta control
- three-phase squirrel-cage induction motors with variable-speed gears (Fig. 42, Fig. 43)
- asynchronous motors with current-controlled rectifier (A.S.S. drive)
- three-phase shunt commutator motors
- DC motors.

Nowadays the following types of motor are mainly used:
- pole-changing motors with special start-up characteristics for ordinary machines
- AC motors with frequency inverters for high-performance machines.

4.3. Three-phase squirrel-cage induction motors

4.3.1. The motor

Three-phase squirrel-cage induction motors are still used in ring spinning mills. They are cheap, require little maintenance, and are wear-resistant and uncomplicated. One disadvantage is their inflexibility, i.e. only one speed is available. This has compelled machinery manufacturers to provide supplementary devices for varying the speed. One such device could, for example, be a star-delta control. While the machine normally operates on delta at full speed, the motor can be switched to star during start-up, thus reducing power output to 1/3, with the speed being reduced according to the load. However, this also usually still results in increased ends down frequency. Other options are:

4.3.2. Pole-changing three-phase motors

Squirrel-cage motors usually have only one 4-pole or 6-pole winding. However, motors can also be produced with two windings, i.e. 4-pole and 6-pole in one motor. By switching from one winding to the other, e.g. from 4-pole to 6-pole, the speed can be reduced to 2/3, since the following relationships exist between poles, frequencies (f) and speeds:

		f=50	f=60
Speed, rpm	6-pole	950	1 130
	4-pole	1 450	1 730

Pole-changing motors are expensive and their efficiency is low since they are load-dependent.

4.3.3. Squirrel-cage induction motors with variable speed gears on the load side

In this case the speed is changed not via the motor, but mechanically via adjustable tapered discs of the belt drive, similar to a cone gear. However, whereas the diameter ratios in a cone gear are changed by moving the belt on the pair of cones, the diameter is changed in this case by pushing together one part and pulling apart the second part of conical drive discs. The drive belt is thus moved to a larger diameter on the first pair of discs and a smaller diameter on the second pair. The change usually occurs in stages by means of a control device via pneumatic or hydraulic pistons and lever arrangements. The basic speed can be adjusted manually. Rieter has also developed an electronic control system with which several speed curves for the spindles can be programmed as required via the variable speed gear.

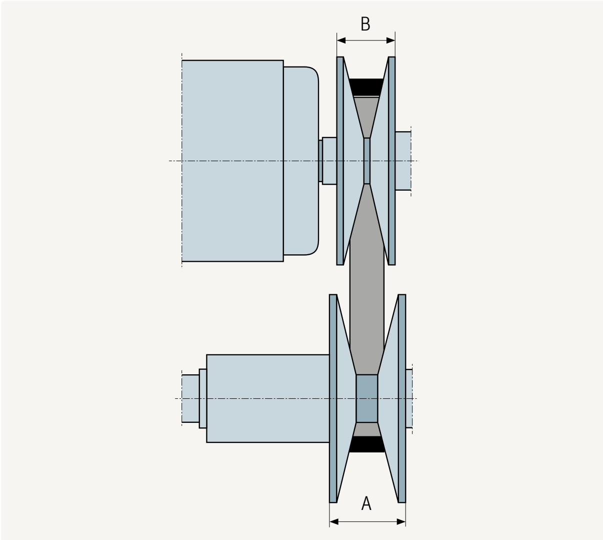


Fig. 42 – Variable-speed gear drive

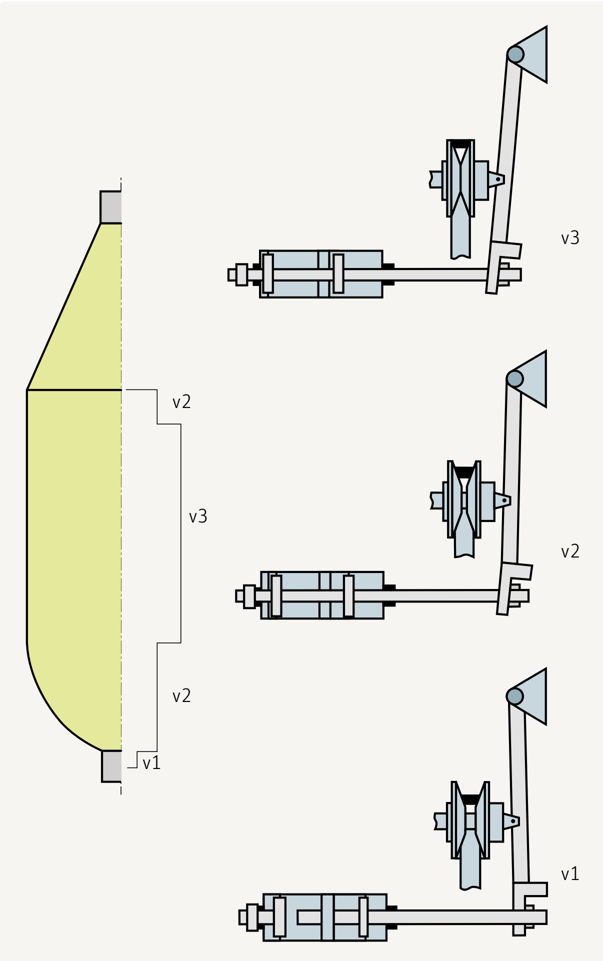


Fig. 43 – Adjustments to the variable-speed gear drive

4.3.4. The A.S.S. drive

Modern high-performance ring spinning machines need very good speed control, i.e. the speed must be independent of variations in load and mains voltage. Absolute observance of the speed ramps is a precondition for good running behavior, mainly during the dynamic start and stop operations. This requirement can be fulfilled easily and at low cost by using a normal asynchronous motor connected to a current-controlled frequency inverter. The additional advantages of this drive system are good overall efficiency, a wide range of motor speeds (0 - 6 000 rpm), simple change of direction of rotation, absence of demand for reactive volt-amperes from the mains supply (cos $\varphi \cong 1.0$) and only a small, i.e. normal load on the power supply system during machine start-up. However, the system needs a sophisticated electronic control system.

4.4. Three-phase shunt motor (commutator motor)

Until a few years ago, this was the only motor that allowed speeds to be adjusted with infinite variation and quite precisely. As a control device for speed adjustment, a so-called „spin controller“ was required as an attachment to the motor, to shift the brushes in the motor accordingly. The speeds were adapted to the changes in yarn tension with the raising and lowering of the ring rail (layering traverse) and during the entire cop buildup (switching traverse). New commutator motors are no longer on offer, as they have serious disadvantages:

- very expensive
- complicated
- high-maintenance (brush maintenance)
- external air cooling
- performance declines in line with speed
- low efficiency
- large space requirements.

4.5. DC shunt motor

This also enables speeds to be adjusted to yarn tension exactly and with infinite variation in a similar way to the commutator motor. Compared with the commutator motor, it has only four brushes with longer service lives and lower maintenance requirements. Efficiency is also higher. However, it is nevertheless rather complicated and not cheap, and therefore little used.

5. COP BUILDUP

5.1. Cop shape

The cop, the typical package shape on the ring spinning machine, consists of three clearly distinguishable buildup sections (Fig. 44):
- the lower, rounded base (A)
- the middle, cylindrical section (Z) and
- the conical nose (S).

The package holder is a tube made from paper, cardboard or plastic, of which some 10 mm at the top and bottom remain uncovered by yarn, and being slightly tapered fits exactly on the spindle. The specific shape of the cop is created by the tapered application of a large number of individual layers of yarn, one on top of the other (see The Rieter Manual of Spinning, Volume 1 – Technology of Short-staple Spinning). Each of these layers consists of a main winding and a cross winding. The main winding, which primarily has to take up the yarn, is usually formed as the ring rail slowly rises, the wide open cross winding during the rapid lowering of the ring rail. Since the cross windings are laid diagonally between the main windings, they isolate the latter from each other. This prevents entire layers from being pulled off during unwinding of the cop in downstream processing (Fig. 45). Compared with other types of winding, such as parallel winding (roving frame), the disadvantage of cop winding is that it requires a more complicated mechanism and winds the yarn with continuously changing tension. However, it is ideal for unwinding on the winder, since it permits high unwinding speeds.

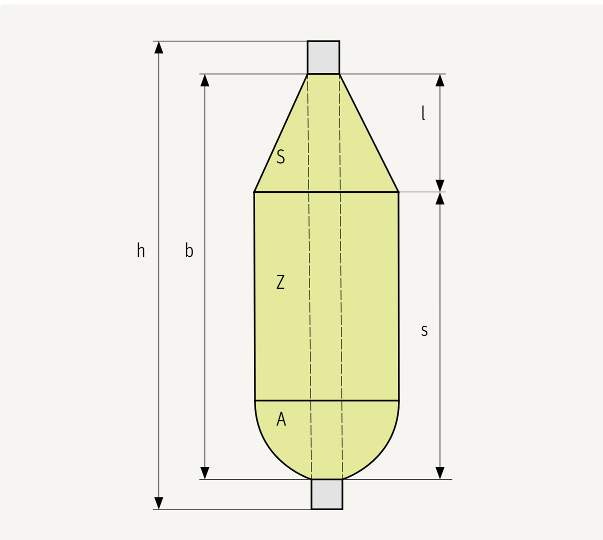


Fig. 44 – Cop shape

Fig. 45 – Main and cross windings

5.2. The winding process

Cop buildup as described here can only occur if the winding point on the tube is shifted continuously. There are two methods of achieving this.

In addition to the constant up-and-down motion of the ring frame:
- the ring frame must be continuously raised or
- the spindle bearing plate must be continuously lowered.

The latter principle has been applied for decades by Rieter for the switching traverse, but is no longer used on new machines. New machines operate nowadays exclusively with a moving ring rail. This now has to perform two movements:
- continuous rising and lowering in order to apply alternate main and cross windings (layering traverse) and
- a continuous ascent in very small amounts after each layering traverse in order to fill the cop (switching traverse).

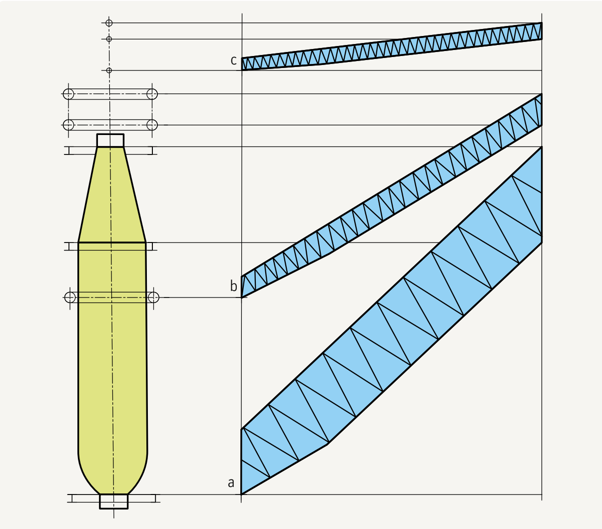


Fig. 46 – Motion diagram for the working elements: ring (a), balloon checking rings (b) and yarn guide eyelets (c)

Both movements have an adverse influence on spinning conditions. In particular, the size of the balloon and the winding diameter on the cop are never the same. This results in wide differences in tension during winding. In order at least to reduce the effects somewhat, the balloon checking rings (b) and yarn guide eyelets (c) perform movements similar to those of ring rail (a), albeit by smaller amounts in both layering and switching traverse. For layer winding the ring rail is usually moved slowly but at increasing pace upward, and rapidly but at decreasing pace downward. This results in a yarn length ratio of about 2:1 between the main winding (upward) and the cross winding (downward), whereby the total length of each double layer should be no more than 5 m (better 4 m) for unwinding purposes. The layering traverse of the ring rail is ideal if it is some 15 - 18 % larger than the ring diameter.

5.3. The winding mechanism

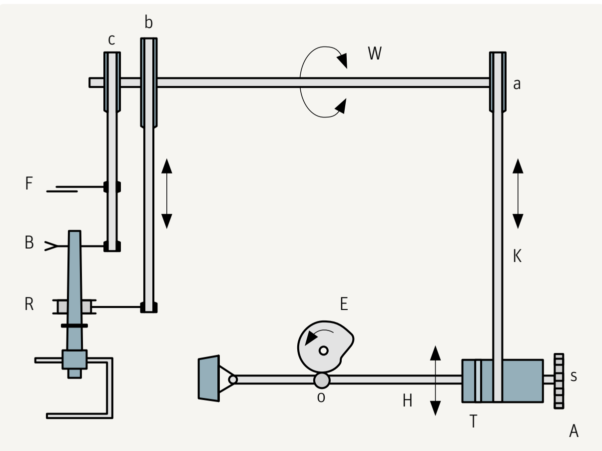


Fig. 47 – Winding mechanism (described on the basis of an example)

Ring rail (R) hangs with its entire weight via belts on disc (b) mounted on shaft (W). At the other end of the shaft is a further disc (a), which presses the entire lever (H) with roller (o) against heart cam (E) via chain (K) and chain drum (T) as a result of the traction of the ring rail. The lever is continuously raised and lowered with the chain drum due to the rotation of the cam. This movement is transmitted to the ring rail via discs (a+b), the chain and the belt, thus producing the layering traverse.

Each time the lever moves down, it presses ratchet wheel (s) against a catch, which results in a small turn of drum (T) connected to the ratchet wheel. Chain (K) is thus wound a small amount onto the drum. This results in a turn of disc (a), shaft (W) and disc (b), and finally a slight raising of ring rail (R) (switching traverse).

However, disc (c) is also mounted on shaft (W) with balloon checking rings (B) and thread guide eyelets (F) suspended on it on belts. These are also raised and lowered accordingly. However, since disc (c) is rather smaller than (b), the traverse motion is also smaller.

5.4. Forming the base

The base is convex in order to accommodate as much yarn as possible on the cop (Fig. 44, A). This convex shape results partly automatically from the specific type of winding, but is also reinforced to some extent by an auxiliary mechanical device, known as a cam, cog, deflector or also by other names (Fig. 48, N).

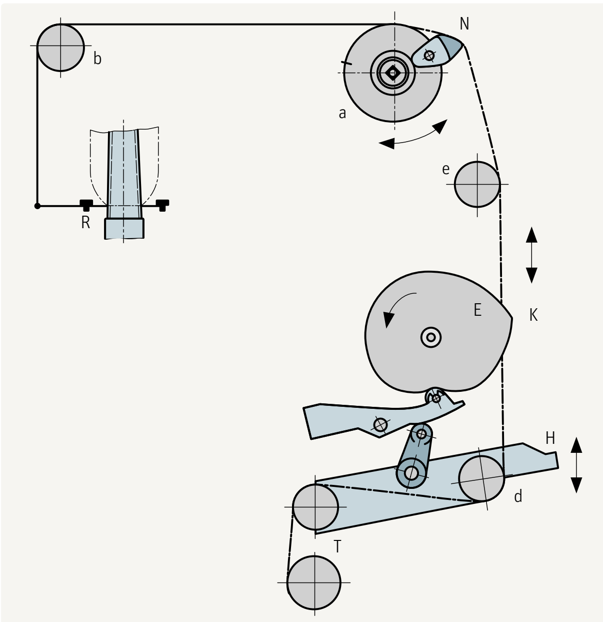


Fig. 48 – Engagement of cam (N) in the winding mechanism

As we have already stated, the raising and lowering of ring rail (R) results from the fact that lever (H) of cam (E) moves up and down and disc (a) is thus continuously turned to the left and right. Cam (N) attached to this disc (a) projects over the periphery of disc (a) and thus increases the diameter of the disc at this point.
When winding on the cop commences, disc (a) is in a position in which the cam deflects chain (K) to some degree, as shown in Fig. 48. As a result of this deflection, part of the elongation of the chain arising from the rise of lever (H) is not passed on to the ring rail, but is lost as deflection at N. The ring rail traverse no longer corresponds to the specification, it is smaller. Since the yarn delivery length per traverse remains unchanged, the bulk per layer is increased, which results in the convex shape referred to above.
If chain winding drum (T) is now turned continuously to the left in small amounts by the winding ratchet wheel in the further course of spinning, and chain (K) is wound up on this disc and thus continuously shortened, disc (a) also turns to the right in equally small amounts, the cam is increasingly less engaged, so that finally the entire elongation of the chain is passed on to the ring rail; the cop is built up normally.

5.5. Motor-powered cop formation

On the latest ring spinning machines the mechanical winding mechanism has been replaced by an electrical drive (Fig. 49). A frequency-controlled motor M is electronically regulated. This motor drives gear G, on output shaft 2 or 3 winding rollers are fixed of which winding rollers for the tie rods of ring rails, balloon checking rings and yarn guides are mounted. This type of powered drive is thus much simpler than the conventional mechanical approaches.

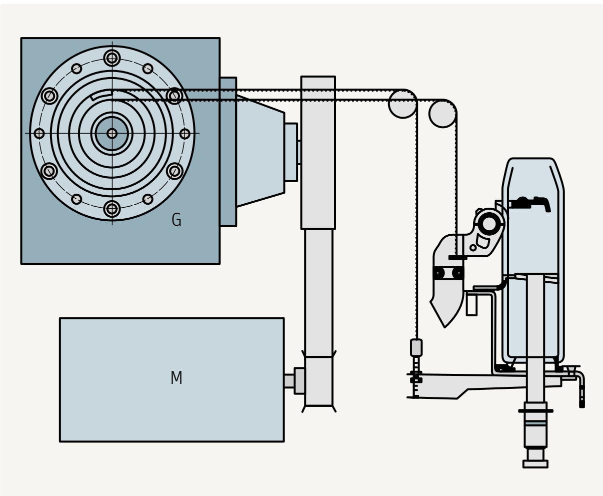


Fig. 49 – Motor-powered cop formation

6. AUTOMATION
6.1. The need for automation

Automation replaces human activity with processes performed by machines, apparatus or electronics. In terms of cost accounting this substitutes capital costs for labor costs. Automation is therefore worthwhile wherever
- lots of manual work has to be done;
- manual work is monotonous or ergonomically unsuitable;
- personnel are scarce;
- the human error factor has to be eliminated.

Since ring spinning accounts for some 50 % of labor costs in a spinning mill, this department is an obvious candidate for automation. However, if we look at the machine itself, it soon becomes obvious that automation is not easy to achieve, since it involves a huge number of tiny production components in a small space with poor accessibility. Even if one or other of these could be automated, it is often uneconomical. Certain operations will therefore have to continue to be performed manually in future.

6.2. The potential for automation

The operations on the ring spinning machine that can be considered for automation are:
- transport of roving bobbins to the ring spinning machine: this automation feature is available, with different automation levels (see The Rieter Manual of Spinning, Volume 3 – Spinning Preparation);
- roving bobbin change: would also be useful, but is difficult to solve; initial units are available;
- roving infeed, eliminating roving ends down: difficult to achieve, doesn‘t often happen, initial approaches exist;
- waste collection and disposal: fully implemented in yarn extraction;
- repairing ends down: calls for complicated approaches which also fail to produce totally successful piecings; currently unfavorable cost/benefit ratio, but would be desirable;
- roving stop motion for ends down: this would be desirable, but the available solutions are complicated and expensive;
- cop change (doffing): already resolved, in full use and described in 6.3.;
- cleaning: largely resolved, albeit unsatisfactorily in terms of quality, by using traversing cleaners;
- servicing and maintenance: the effort involved is much less than it used to be, but a certain amount still has to be performed manually;
- transport of cops to the winders: automation of this process is available and has become well established in mill operations;
- machine monitoring: good solutions (e.g. Zellweger Ringdata) are available on the market;
- production and quality monitoring: good solutions are also available here (e.g. SPIDERweb);
- yarn uniformity monitoring: this cannot be performed economically for each spinning position.

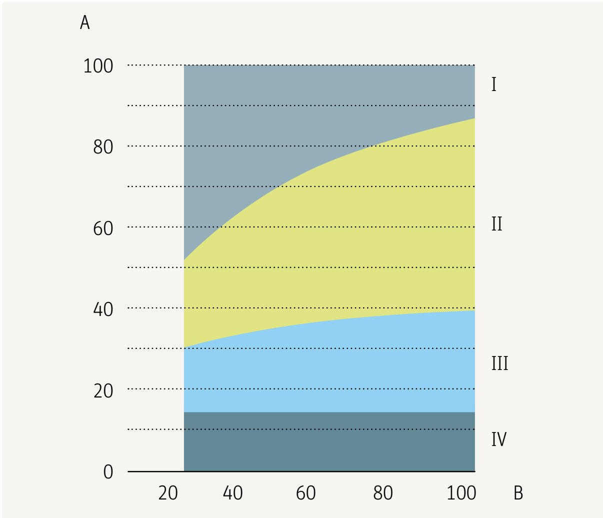


Fig. 50 – Work performed by a ring spinning operative
A: percent, B: yarn count in Nm,
I: roving supply, II: monitoring, III: yarn piecing, IV: allowance

However, we must not lose sight of the fact that, with each further stage of automation that eases the workload on the operative, spindle allocation must be increased, which in turn causes an irresponsible increase in inspection tour times in some cases. This finally necessitates intensified monitoring, e.g. indicating to operatives by means of signals (lamps) the exact position within their sphere of operations at which their presence is currently required.

An analysis of the work performed by a spinning mill operative at 20 ends down per 1 000 spindle hours and an inspection tour time of 15 minutes illustrated in a graph produced by the Zinser company (Fig. 50, W. Igel „Automation of ring spinning machines“, Reutlingen Colloquium, Nov. 1984) shows how important this is. The amount of monitoring is very conspicuous here, consisting of a large proportion of unproductive time.

6.3. Doffing

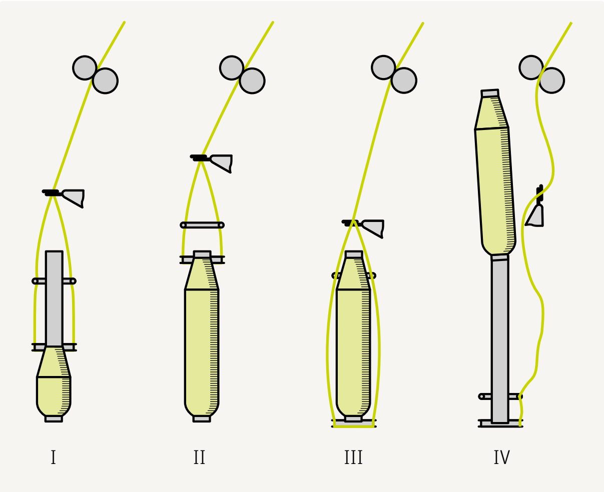


Fig. 51 – Preparation for doffing

6.3.1. Preparation for doffing

For process-related reasons a cop takes up only 30 - 100 g of yarn. Nevertheless, it takes 1 - 30 hours to fill it. The limited capacity of the cop compels yarn manufacturers to add a further process subsequently, i.e. rewinding. Another drawback of the small package is the need to doff the full cop at relatively short intervals and replace it by an empty tube - a rather complicated process. Several preparatory operations have to be performed so that this change can be made rationally and without causing higher rates of ends down (Fig. 51) .

If the empty tubes have been prepared for the change and if the ring rail has reached its uppermost position (II), the ring rail and the balloon checking rings are lowered (III) in order to reach the cop more easily. At the same time the yarn guide eyelets are tilted upward (IV), since only then can the cop be removed over the spindle. The ring rail is moved to a lower position (Fig. 52) than that at which the new winding operation then begins (a). The lower position is referred to as the underwinding position (b) and the starting position as the piecing position (a). The underwinding position has a specific function – it produces a thread reserve. This is because yarn continues to be delivered while the ring rail is being lowered and several turns are wound around the finished cop as a so-called reserve winding (Fig. 53). This should consist of no more than 3 - 4 turns, perhaps only 1 1/2 to 2 turns in the case of high-tenacity yarns.

When the ring rail reaches the underwinding position (2), delivery is still not interrupted, so that several yarn turns attach themselves here as a yarn ring. During manual doffing this

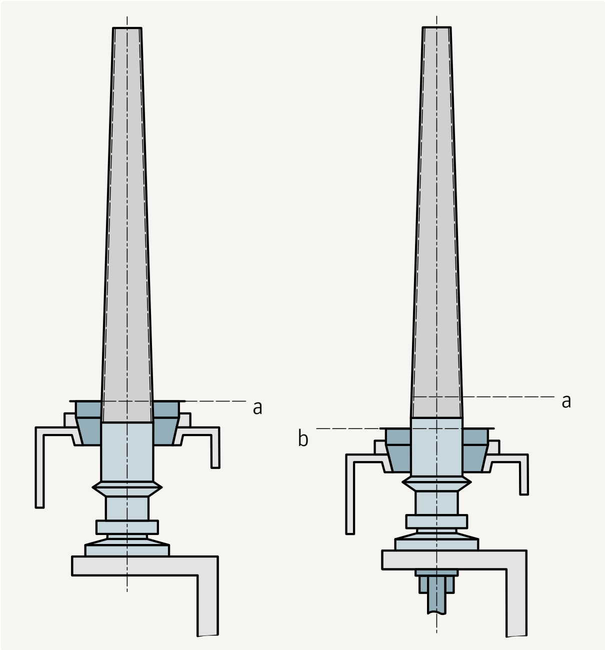


Fig. 52 – Underwinding position (b) and piecing position (a) of the ring rail

thread reserve is still on the tube, during automatic doffing it is on the spindle. The reserve is necessary so that the yarn continues to be held on the spindle when the cop is doffed. Otherwise a yarn break would occur. Various systems are currently known that actively clamp the yarn on the spindle in order to keep the reserve thread as short as possible and thus virtually eliminate the disturbing yarn residues occurring later when the reserve is removed. On modern machines all these preparatory processes for doffing occur automatically.

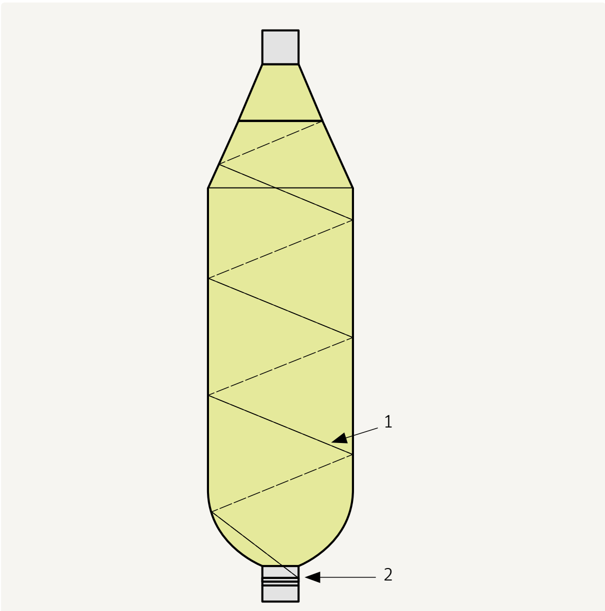


Fig. 53 – Reserve winding (1) and underwinding (2)

6.3.2. Manual doffing

Doffing used to be performed only by hand. Nowadays doffing is still performed manually for the most part in countries with low wage levels. Operatives would grasp the full cop with their left hand, lift it off the spindle and replace it on the spindle with an empty tube in their right hand before the thread could break between the cop and the spindle. Personnel would do this spindle by spindle, while pushing two boxes with their knee along the longitudinal rails attached to the machines. One of these boxes would contain the empty tubes, the full cops would be placed in the other. Doffing would be performed by groups in so-called doffing teams, with a specific section of the whole machine always being allocated to each operative.

Manual doffing is an unattractive job, since only a very few actions have to be performed very quickly and constantly repeated, and the work usually has to be done in a slightly stooping posture. It is very difficult to find personnel for this in industrialized countries. However, manual doffing also has the advantage that the doffing team represents a personnel reserve that is available at any time.

6.3.3. Automatic doffing
6.3.3.1. Types of doffing system

A distinction is made between two groups of so-called autodoffers (automatic doffing systems):
- stationary systems integrated in each ring spinning machine, and
- mobile systems which can serve several machines.

When new machines are equipped with automatic doffing systems, these are almost always stationary systems. Mobile systems are used, if at all, almost exclusively in existing ring spinning mills. They are somewhat susceptible to faults and require considerable maintenance effort. Whereas with stationary systems all cops on a machine are doffed simultaneously, mobile systems usually feature individual doffing, often also doffing in groups. A stationary system is described below as an example for many other options.

6.3.3.2. Components of the system

Essentially, these systems consist of (Fig. 54):
- a conveyor belt (T) equipped with discs to hold tubes (or cops), or a conveying mechanism with support discs arranged one behind the other on narrow rails for pushing the discs along the machine. In both cases the discs serve to convey the tubes prior to doffing and the cops after doffing;
- a doffing rail (B), also extending along the entire length of the machine, equipped with pegs (Z) which engage with the tubes (Zinser) or collars to grip the outside of the tubes and cops;
- a system of lifting levers (G), usually in the form of tongs, to raise and lower the rail and swivel it in and out;
- a tube preparation and creeling device at the end of the machine; and
- a cop storage device, also at the end of the machine, or a cop transfer unit to a directly connected winder.

6.3.3.3. Doffing preparation

All the operations already referred to have to be performed fully automatically here. In addition, there is the special preparation of tubes at the tube loading station. Conveyor belt (T) starts to move along under the loading unit some time before the cops are full. In the process the tubes supplied in tube boxes are inserted on the pegs of the conveyor belt so that every other peg is unoccupied. These pegs later accommodate the full cops. During this operation the conveyor belt moves slowly into its working position, until an empty tube and an empty peg are positioned in front of each spindle.

6.3.3.4. Doffing the cops

The doffing system is in the idle position as long as the cop is being wound (Fig. 55). Once the cop is fully wound, lever system (G) moves out with rail (B), while the levers raise the rail (Fig. 56). After reaching their uppermost position the rods retract again, the rail is positioned over the cops and is now lowered until the pegs engage in the tubes of cops (K). Instead of pegs, the cops can also be gripped by collars which enclose the cops. Gripping and holding are effected by inflating the pegs or collars, or by means of tubes.

Once the cops are gripped, rail (B) is raised together with the cops (Fig. 57), the rods are extended, lower the rail and move it over conveyor belt (T), and deposit the cops (K) on the conveyor belt (Fig. 58). The compressed air is then discharged and the cops are released.

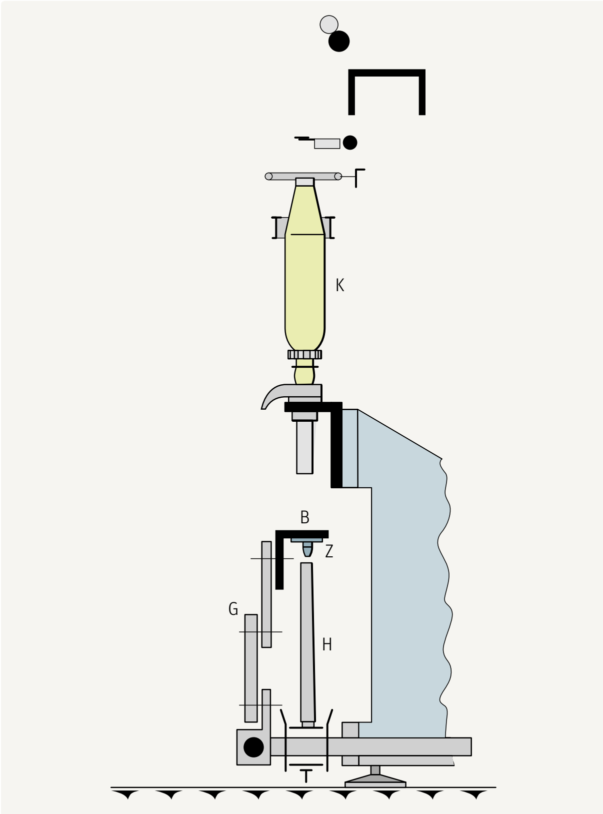


Fig. 55 – Autodoffer prior to doffing

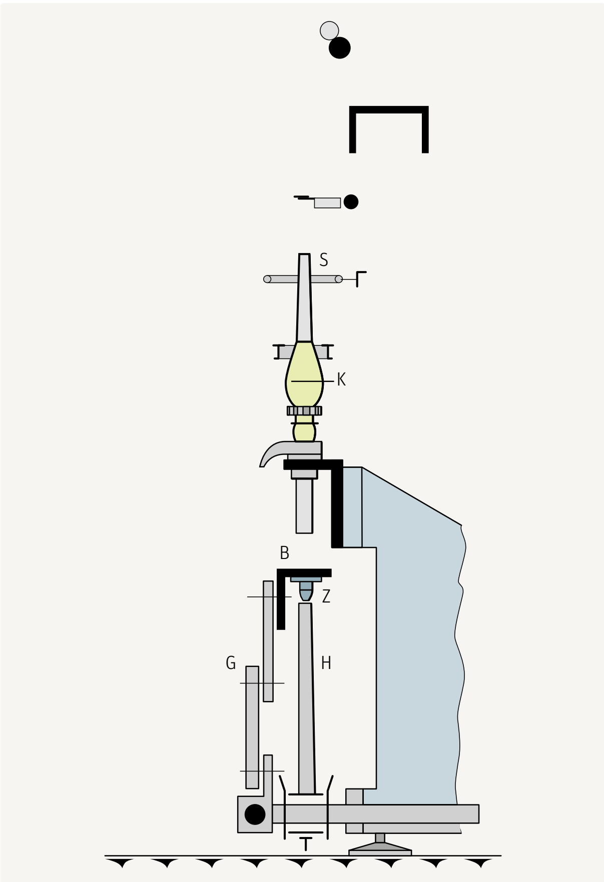


Fig. 54 – Autodoffer retracted

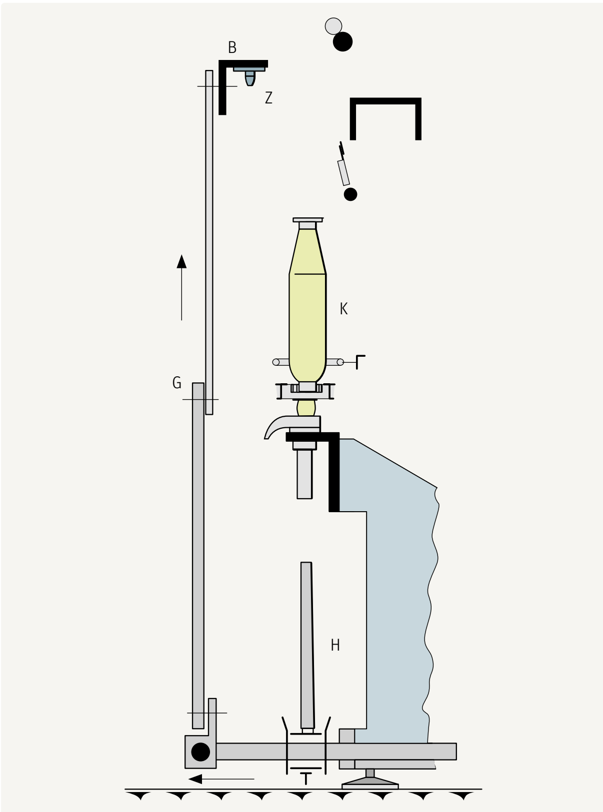


Fig. 56 – Extending the doffer rail (B)

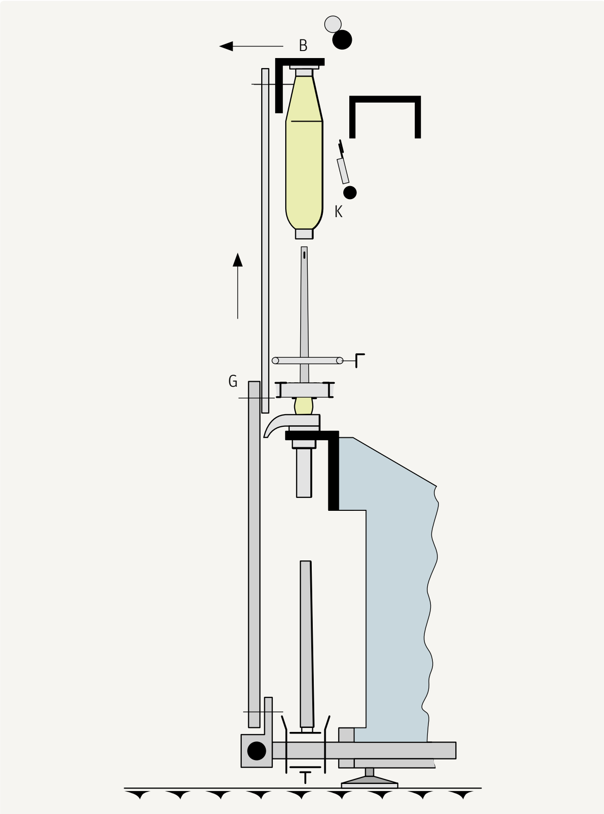


Fig. 57 – Raising the full cops (K)

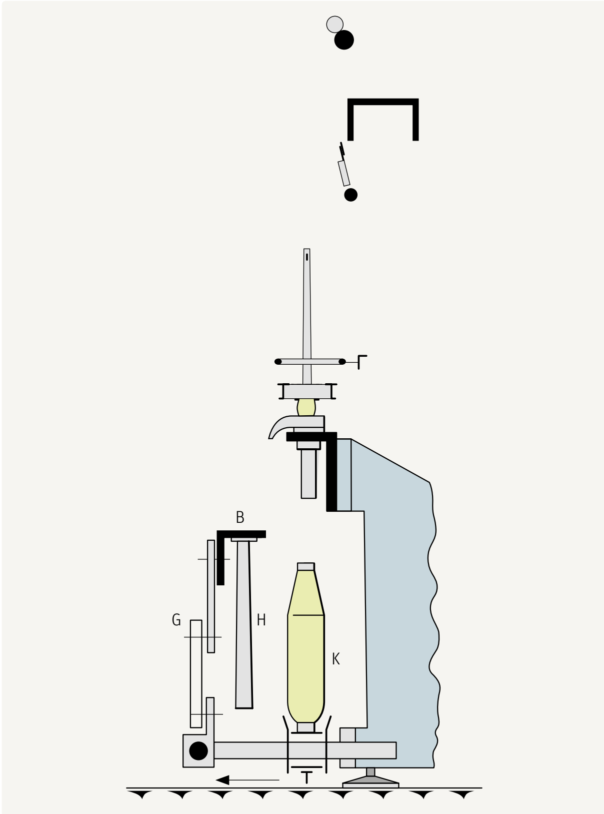


Fig. 59 – Gripping the empty tubes (H) and extending

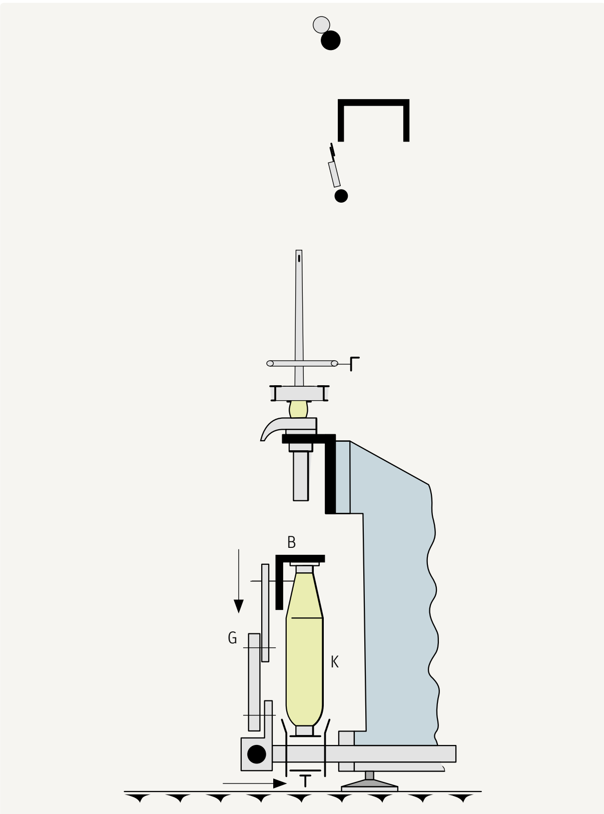


Fig. 58 – Lowering and releasing the full cops (K)

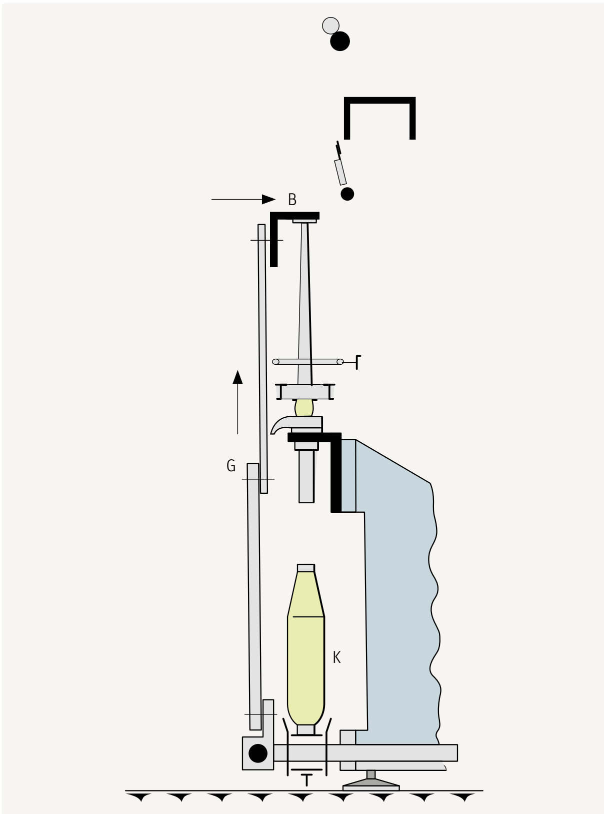


Fig. 60 – Creeling the tubes (H)

6.3.3.5. Creeling the tubes

Rail (B) remains over conveyor belt (T), but rises slightly. Then the conveyor belt moves half a spacing forward so that the empty tubes reach a point exactly under the pegs on the rail. When the rail is then lowered again and compressed air fed in, the pegs engage in the empty tubes (H) and hold them firmly. The lever system is then extended again (Fig. 59), the rail is raised, moved in over the spindles and lowered with tubes (H) onto the spindles and then pressed on firmly (Fig. 60). Once again the discharge of compressed air releases the tubes.

6.3.3.6. Completion of doffing

During automatic doffing with old doffing systems the process is interrupted once or twice for tours of inspection. Personnel need to check that the process is proceeding correctly, and especially to ensure that tubes have been fitted everywhere and are not jammed. These tours of inspection are no longer necessary on good modern doffing systems, since each spinning position is continuously monitored during doffing, and collisions between tubes and spindles or cops are therefore impossible. After doffing is completed, the doffer returns to its idle position below the spindles. At the same time the ring rail rises to the piecing position, the balloon checking rings move upward and the yarn guide flaps tilt downward. The machine starts. The conveyor belt moves the doffed cops toward the end of the machine, where they are discharged into transport trolleys or individually transferred directly to the winder. Duration of automatic doffing can be as short as 2 minutes.

6.4. Automated cop transport

6.4.1. Appropriateness of automation

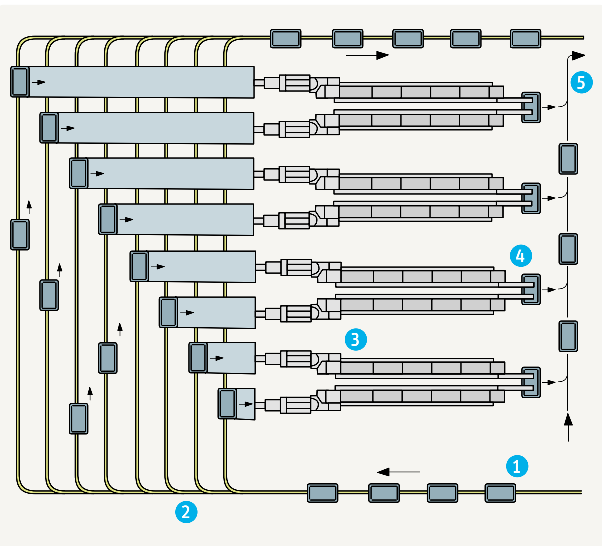


Fig. 61 – Yarn transport from the ring spinning machine to the winder (as proposed by Schlafhorst)

When we look at the manufacturing processes used in the textile industry, spinning involves a mixture of workshop and production line operations, with the workshop the predominant feature. The installation consists of many manufacturing stages forming self-contained departments, with the different intermediate products usually being transported in quite large units from one department to the next and also usually being stored between the different stages. Material therefore hardly flows along the shortest path in regular cycles from a production unit directly to the same downstream operation every time. This type of manufacturing process has four serious drawbacks:

- high transport costs (more than 60 % of a spinning mill's wage costs are transport costs)
- long material lead times (with correspondingly long delivery lead times) and
- intermediate storage of large volumes of material (substantial amounts of capital tied up)
- deterioration in quality, damage to the material.

It is therefore hardly surprising that there is a steadily increasing awareness of the importance of transport in spinning mills and among machinery manufacturers and that opportunities for improvement are being sought. Several textile machinery manufacturers are already offering automated transport systems. A distinction has to be made between two types of automated transport equipment between ring spinning machines and winders:

- interconnected transport and
- interconnected machines.

6.4.2. Interconnected transport

In interconnected transport an automated transport system (conveyor line) is installed between the ring spinning installation and the winders. The transport system accepts the cop crates – coded according to their contents – at the ring spinning machine and conveys them to a distribution station. This station directs the crates by microprocessor control to their correct destination, a cop preparation unit on the relevant winder. The resulting empty tubes are laid in other crates and return to the ring spinning installation via a second conveyor system. Interconnected transport systems:

- are very flexible
- permit operations with small batches
- can quickly be adapted
- are less dependent on the building.

However, they can be rather complicated, liable to malfunction and obstructive due to the conveyor lines.

6.4.3. Interconnected machines

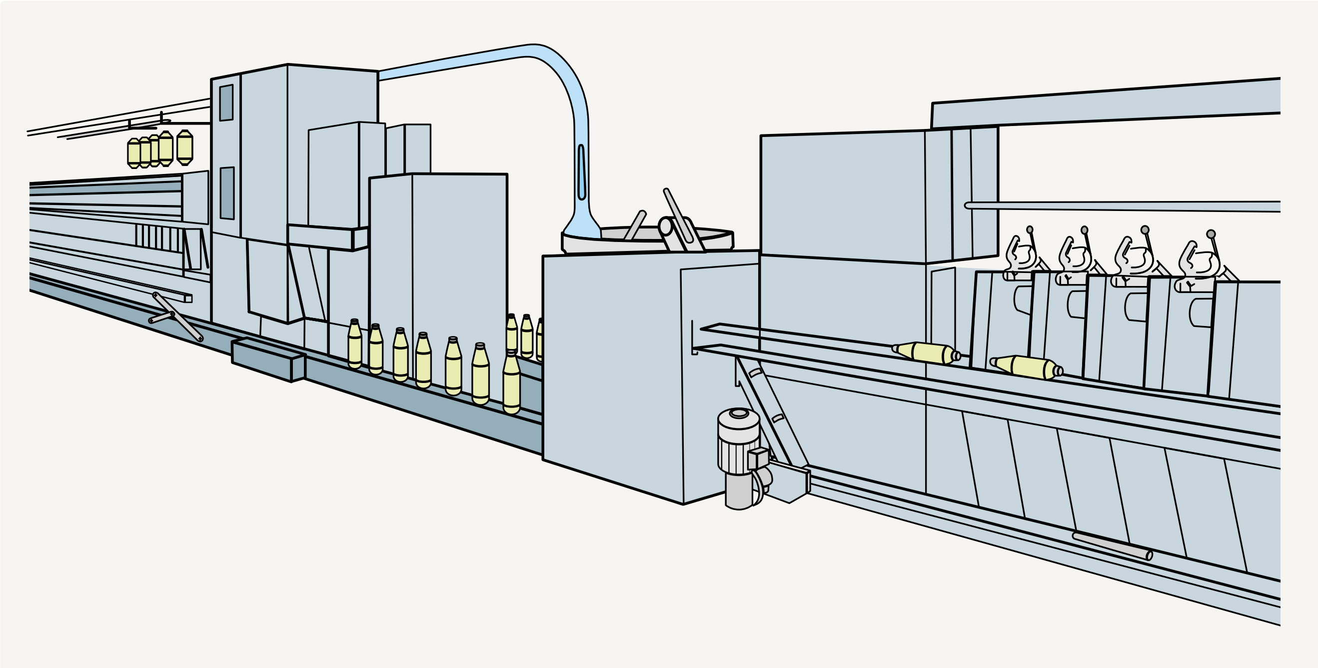


Fig. 62 – Interconnected machines: ring spinning machine and winder

In new installations or older buildings of appropriate and modern design (e.g. Gherzi buildings) more efficient systems can be employed, e.g. by connecting two machines (ring spinning machine and winder) to form a production unit. As shown in Fig. 62, in these cases the cops pass slowly, i.e. at the production speed of the winder units, in a direct line to the downstream winder after doffing. Emptied tubes return to the doffer's loading station on the ring spinning machine. The number of winder units has to be chosen to ensure that the winding of a doff is completed exactly when the next approaches. This exact coordination of the two machines can be a drawback of the system if there are frequent yarn count changes, since reserve winding capacity – which often remains unused – then has to be installed to provide for every eventuality. This results in higher capital service costs. These systems are therefore ideal when operating as far as possible with only one yarn count.

6.5. Piecing devices

Installing piecing units at each spinning position is too complicated. Mobile piecing carriages mounted on rails attached to the machines are therefore used. The piecing carriages then have to perform the same, rather complicated, detailed operations as spinning personnel, but by mechanical means:

- detecting ends down by rotating around the spindles
- stopping at the right place
- accurate positioning relative to the spindle
- stopping the spindle
- finding the yarn end
- moving the ring traveler into the threading position
- drawing the yarn into the ring traveler
- releasing the spindle
- spinning the yarn onto the fiber ribbon emerging from the front roller.

The whole process proceeds as follows (example: FIL-A-MAT by Zinser). During its inspection run along the ring spinning machine the FIL-A-MAT examines each individual spinning position photoelectrically for ends down. If a yarn is present it continues its run and examines the next spinning position. If it detects a yarn break, it stops in the working position in front of the spindle, extends the frame with the working elements and centers it precisely on the spindle bearing. The spindle is braked. Another working unit descends onto the ring rail and follows its motion during the subsequent operations.
The yarn end is then blown upward from the cop into the funnel-shaped opening of a suction tube. The yarn end can be at any point on the winding circumference. In the same way as the hand of a spinning operative, the yarn hook

catches the yarn between the top of the tube and the yarn guide eyelet, lays it on the spinning ring, and the piecer arm joins it to the fiber bundle on the delivery roller of the drafting system. The remaining yarn residue is separated and extracted. A photocell monitors the success of the operation. The piecing process is repeated once if necessary, then the FIL-A-MAT leaves manual piecing to personnel.

Piecing devices can be used simultaneously for machine and production monitoring as well as roving stop motions, as was the case with Rieter's ROBOfil.

All these devices are no longer available for sale.

6.6. Roving stop motions

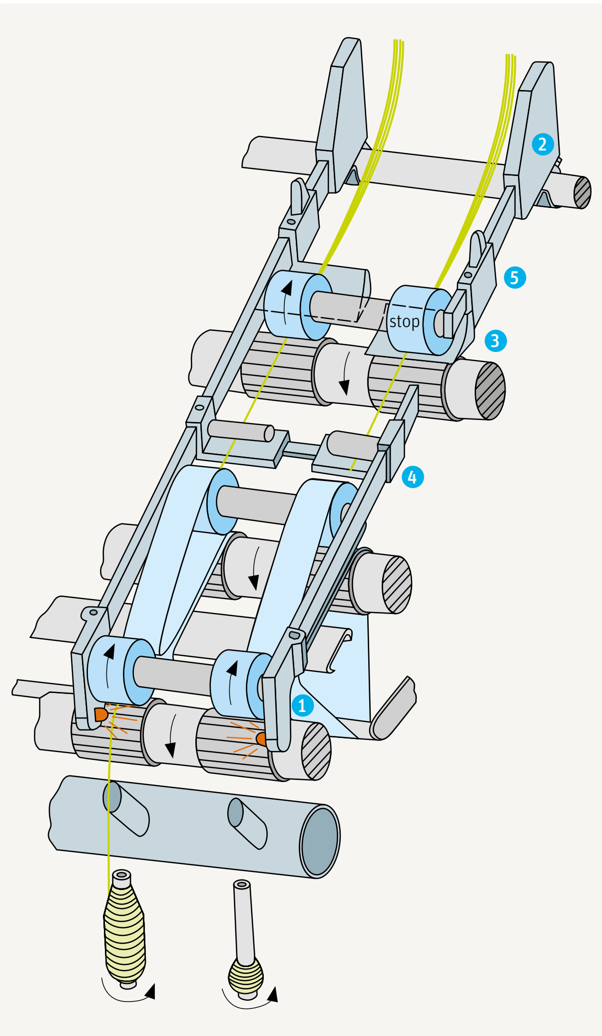


Fig. 63 – SKF roving stop motion

If a yarn breaks on a ring spinning machine, the fiber ribbon continues to emerge from the drafting mechanism, usually into the fiber extraction system. However, in poor spinning conditions it often happens that the ribbon wraps around a cylinder or a roller and causes a lap. This in turn can result in damage to the top rollers, aprons, etc., deformation of the bottom roller or simply breaks in neighboring threads. Removing laps is also quite complicated and laborious. It would therefore be desirable to interrupt the flow of fibers at each thread break until piecing is completed. However, the roving would then have to be inserted again automatically.
Roving stop motions can be part of a rotating carriage or individual units for each spinning position. Units in rotating carriages are less expensive, but do not stop immediately in the event of a thread break – as do the individual units – since they first have to find it.

The SKF roving stop motion (which is no longer available for sale) is outlined briefly here on behalf of all other individual units (Fig. 63). The monitoring optics check the threadline. In the event of a thread break, roving feed is interrupted via optical unit 1 and electronics 2 via wedge 3. The table and possibly pivot 4 retain the roving firmly in the break draft zone. After the yarn break has been repaired, wedge 3 is retracted manually by means of roving locking device 5. The roving is delivered and spinning can commence.

6.7. Monitoring

6.7.1. The purpose of this equipment

Monitoring devices on the ring spinning machine move back and forth on each side of the machine or are installed as stationary units at each spinning position. They can perform one, several or all of the following tasks:

- detecting and signaling ends down
- detecting and repairing ends down
- detecting and recording ends down
- detecting and analyzing ends down by:
  - number
  - duration
  - faulty spinning positions, etc.
- recording stoppages
- recording output
- calculating efficiency
- roving stop motion in the event of ends down.

Downtime, output, efficiency and ends down records provide the mill with extremely important information for:

- workplace loading
- personnel rating
- cost calculation
- assessing the spinning behavior of different raw materials
- assessing the production behavior of individual machine components, such as:
  - cylinders
  - rollers
  - aprons
  - spindles
  - travelers
  - rings, etc.
- establishing the causes of faults, overall and per spinning position
- assessing climatic influences
- operator guidance to enable spinning mill personnel to move systematically from one yarn break to the next without covering unnecessary ground.

6.7.2. RINGDATA by Zellweger

A traveling sensor runs continuously back and forth at the height of the ring rail on each side of the machine on a single machine (pilot unit) or on all machines in the mill. This generates a magnetic field that is affected by the rapidly rotating traveler. If a yarn break occurs, the traveler ceases to rotate and the sensor displays the resulting impulse as an end down, also recording the number of the spindle. As a result of its rapid motion back and forth it registers the spindle several times until the end down is repaired. The spindle downtime is therefore also recorded. Another sensor fitted on the front roller records the delivery speed and machine stoppages, and another the number of doffs and their duration. All the information collected is ultimately transmitted to a computer with monitor and printer, which performs the necessary analysis and stores the data for preset periods. The following data are available via reports on individual machines, individual blends or the installation as a whole that are printed out or can be called up on the monitor:

- machine number
- date
- time

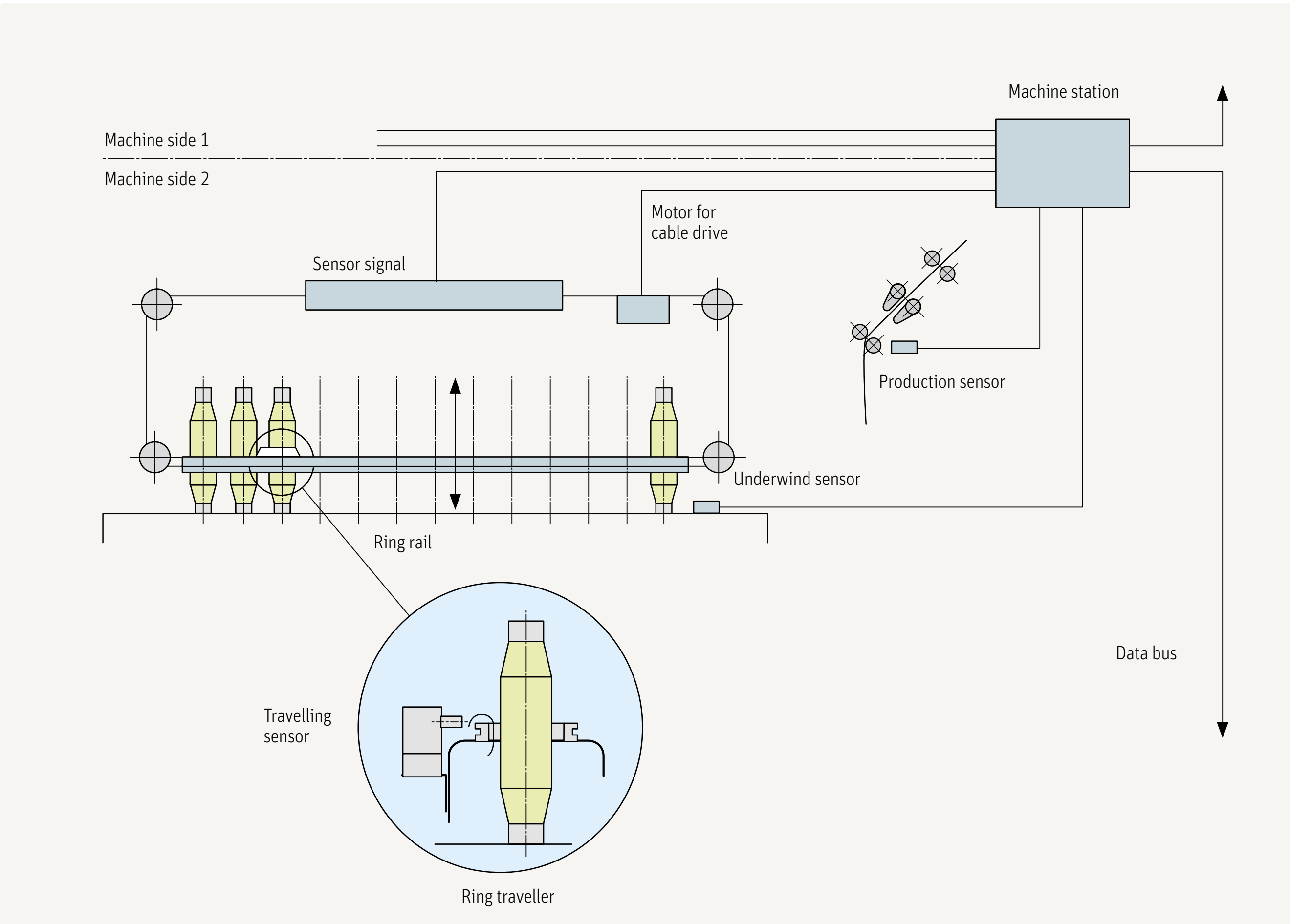


Fig. 64 – USTER Ringdata

- period monitored
- production period
- spindle speeds
- yarn twist
- output in kg
- output in g/spi.h
- efficiency
- downtimes
- doffing times
- number of cops doffed
- number of ends down
- ends down per 1 000 spindle hours
- mean duration of ends down
- preset maximum number of ends down
- number of spindles with ends down exceeding this limit.

6.7.3. Individual Spindle Monitoring (ISM) by Rieter

This system features an optical sensor on the ring frame at each spinning position, which monitors the motion of the traveler. It can therefore perform 3 operations:

- recording ends down (incl. startup ends down following cop changes) and registering spindles rotating too slowly (so-called slipper spindles)
- convenient analysis and presentation of these data in the SPIDERweb system
- operator guidance in 3 steps:
  - signal lamps at both ends of the machine indicate when an ends down limit has been exceeded
  - a LED for each 24 spindles indicates that an end is down in this section
  - a LED at each spinning position indicates an end down or a slipper spindle.

This individual spindle monitoring system has distinct advantages:

- no moving parts
- no maintenance
- continuous monitoring of all spindles.

6.7.4. Mill information systems

6.7.4.1. Requirements

High-tech spinning plants cannot be operated without management information systems based on online quality assurance and productivity control. High-performance machines such as cards, draw frames, etc., produce enormous amounts of intermediate products in a very short time; for example, in one minute a draw frame operating at a speed of 800 meters per minute produces sufficient sliver for 57 cops of yarn or 26 shirts. The volume of rejects is correspondingly high if anything goes wrong at any production unit. Any drifting off target therefore has to be prevented by any means from the very beginning. The slogan: Faults should be prevented, not corrected is valid here more than ever.

However, this cannot be achieved merely by means of the time-honored "Statistical Quality Control Department". Over and above this, highly competent quality management and an overall control and information system with control devices at all the production units is required either for individual machines or group-wise. This has to start at the point where the first intermediate product is created, i.e. at the card, and has to continue as far as the winders. As sensors are to be installed on the machines in any case for quality assurance purposes, it makes sense to equip these control units additionally with data collecting and data evaluation systems to obtain a most important tool not only for quality management but also for mill management. Systems of this kind for controlling the process in terms of quality and economy are available from a number of machinery or instrument manufacturers, either for individual machines or groups of machines, including:

- Rieter: ABC control for blowroom and cards
- Schlafhorst: Corolab for rotor spinning
- Trützschler: KIT for cards, CIT for spinning preparation, SIT for blowroom and cards.

Or for controlling and managing the entire spinning plant, e.g.:

- Rieter: SPIDERweb
- Zellweger: POLYLINK and others.

6.7.4.2. Structure of mill information systems

Most of these systems feature a three- or four-level structure, starting at the lowest level, the sensor level, in which sensitive sensors are installed directly on the production units to record quality and/or production data. They continue to higher levels, e.g. the machine level, where the signals arriving from the sensors are collected, processed and analyzed, and the result often indicated in a simple manner on the machine. The third level is the PC workstation level, where the data collected at machine level are systematically evaluated and displayed in a very informative way in the supervisor's office, for instance in the form of graphs.
The top level is usually a commercial host computer. Here again all the information arriving from the second or third level is collected in a condensed and compatible form by a local network, systematically evaluated and displayed in

a manner easy to deal with, e.g. in diagram form (Fig. 65). The detailed analysis of the second, (third) and fourth level enables immediate action to be taken wherever anything strays even slightly from the required norm.

6.7.4.3. Explanation of the Rieter SPIDERweb system by way of example

SPIDERweb is a modern, user-oriented, Windows-based data system. Fig. 66 shows the corresponding dataflow in schematic form. Within the mill, this dataflow is based on Ethernet. This both simplifies data management and enables data loss to be prevented efficiently. Data are stored in 3 locations for this purpose:

- on the machine, until they are written onto the customer‘s PC
- on the hard disc of the host PC, until they are written into the SPIDERweb database
- in the SPIDERweb database for up to one year. External backup of this database is possible.

Data in a condensed and evaluated form is thus available:

- within the mill, wherever it is required
- worldwide, using additional pcAnywhere™ software.

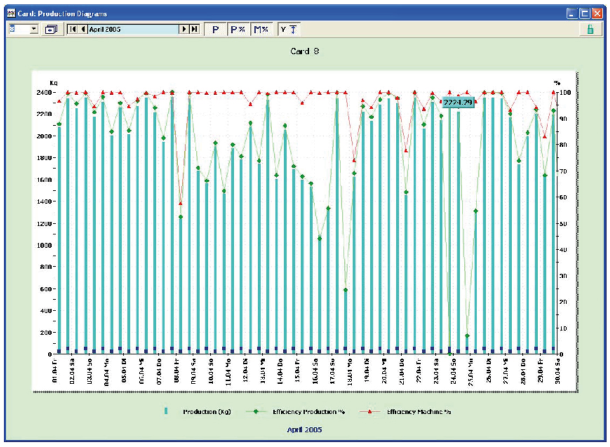


Fig. 65 – Diagram of the card production

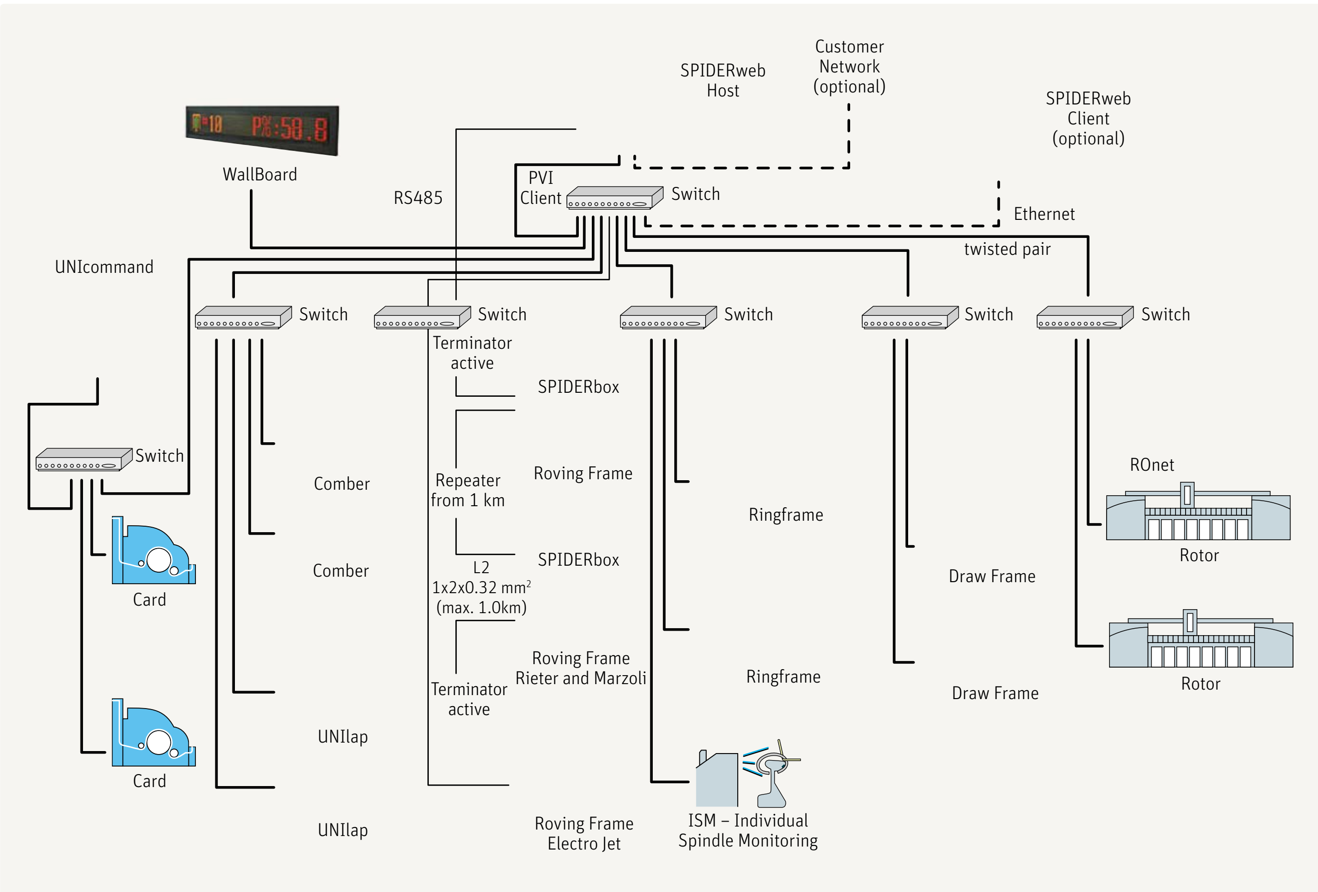


Fig. 66 – SPIDERweb network

7. AUXILIARY EQUIPMENT

7.1. Fiber extraction

7.1.1. The system

It is impossible to imagine a modern ring spinning machine without fiber extraction. This not only ensures that fibers which emerge from the drafting system after a thread break are removed, thus preventing serial ends down, but also improves air conditioning, since it directs a large proportion of the return air from the air conditioning system past the drafting system and in particular the spinning triangle. In modern systems as much as 50 % of the return air returns to the air conditioning system via fiber extraction.

A fiber extraction system (Fig. 67) consists primarily of a central duct (K), which passes through the entire machine at the level of the drafting system, featuring a large number of suction tubes (D) leading from the duct to each spinning triangle. The required vacuum is generated by a fan (V). Before the exhaust air reaches the air conditioning system via exhaust air duct (A) it passes through filter (F), in which the fibers are removed. These filters are preferably designed as rotating filters with automatic cleaning.

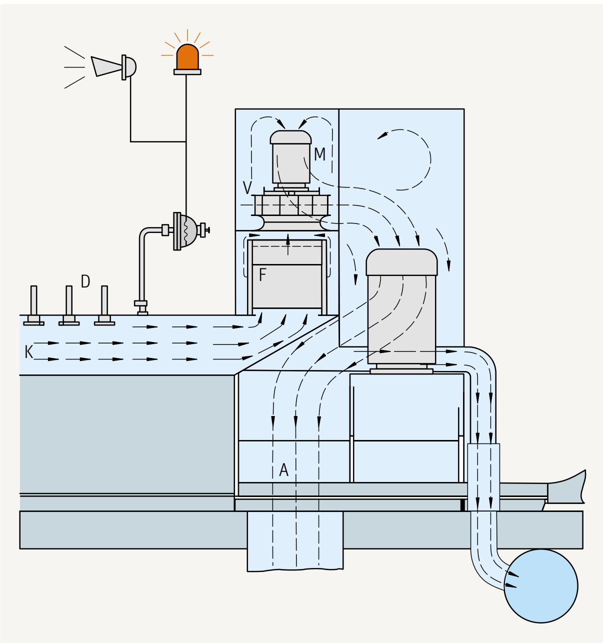


Fig. 67 – Fiber extraction

7.1.2. Vacuum and energy consumption

A relatively high vacuum is necessary to ensure reliable extraction. It should be approx. 600 to 800 Pa for cotton and approx. 1 000 to 1 200 Pa for manmade fibers. It should be

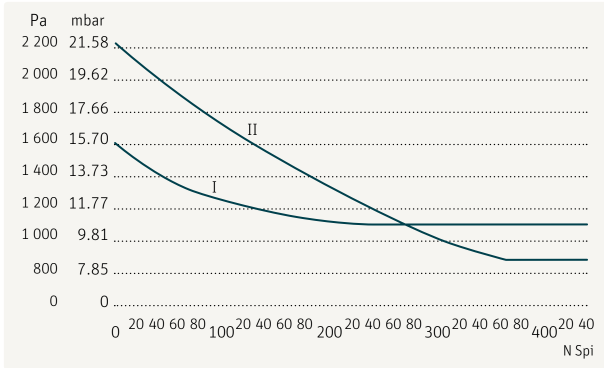


Fig. 68 – Pressure drop in the fiber extraction system, starting from the first spindle on the fan side; N -spindle No.; I: short machine; II: long machine

borne in mind here that there can be a considerable drop in pressure between the fan and the last spindle. The longer the machines (Fig. 68) and the larger the air flow rate, the greater the drop in pressure. The air flow rate is usually between 5 and 10 m^3/h. The energy consumption required for fiber extraction is substantial. It can account for up to 1/3 of the machine's drive power and also depends on the length of the machine and the air flow rate. For example, energy consumption at 10 m^3/h is 4.5 times higher than at 6 m^3/h, due to the considerably higher vacuum.

7.2. Blowers (traveling cleaners)

7.2.1. The problem of dust and fly

Many short fibers are lost as fly during the processing of staple fibers on spinning machines, and a considerable quantity of fiber debris and dust is released. Fly and dust are deposited on machine components or are continuously being whipped up and around by rotating and circulating devices such as spindles, drums, drive wheels, etc. They have therefore always been a significant disturbing factor as regards service and maintenance as well as diminishing quality. This problem has intensified further with high production speeds and high drafts. The most fly and dust on ring spinning machines is released in the main drafting zone and the spinning triangle (up to 85 %), while the balloon and travelers account for most of the remainder. Since it is impossible to prevent fly from being released, provision should at least be made for removing it. Whereas this always used to entail manual cleaning of the machine components, blower devices are mostly used for this nowadays. However, it has to be said that blower devices do not function ideally, since they blow fly and dust off the machine components rather than removing them at the place where they occur, and therefore also whirl them over the machines. The accumulations of dust and fly therefore do not always end up where one would like them to. They can thus again result in disturbances. However, no better solutions are known at present.

7.2.2. Types

The types of device are differentiated as follows:
- agitators
- blower devices
- suction devices
- combined blower/suction devices

by the way they are utilized on the machines:
- individual units, i.e. devices for cleaning only one machine, and
- collective units, where one device traverses 2 - 8 machines

and by their mode of circulation:
- rotating and
- reciprocating.

Combined blower/suction devices operating as reciprocating collective units are currently very widely used.

7.2.3. Agitators

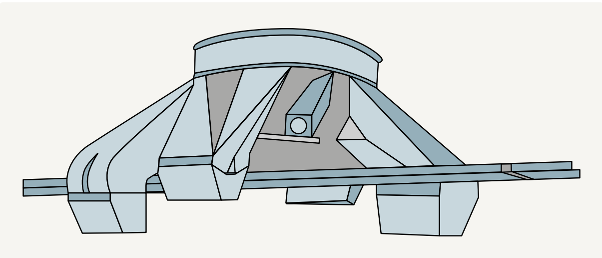


Fig. 69 – Agitator

These are simple fans with short blower nozzles driven by a small electric motor, circulating on conductor rails over the machines. They are now only used, if at all, on winders, as they cannot clean selectively.

7.2.4. Blower/suction systems

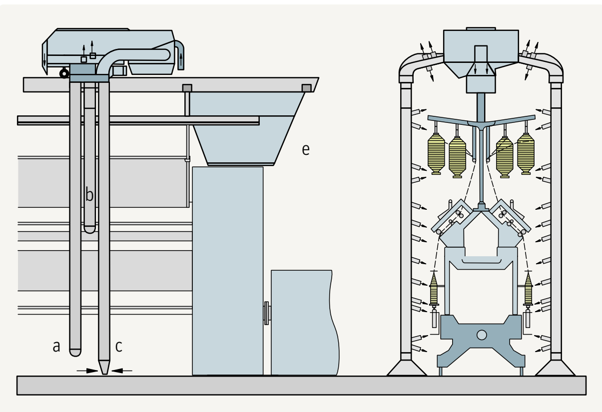


Fig. 70 – Blower/suction system

The devices most widely used nowadays operate like agitators, but with significantly higher performance (- 3 kW, - 5 000 m^3/h of air, up to 50 m/sec air speed at the nozzles) and feature several hoses, some of them reaching to the floor. One or two of these hoses on each side blow (a+b) and one (c) sucks the material which has been blown off up from the floor. The blowing hoses feature blowing nozzles at different heights, aimed precisely at the exposed zones in such a way that as far as possible they blow the fly downward.

A filter with a filter cleaning device is a logical necessity when working with suction systems. On the Sohler system, for example, the traveling cleaner passes over a collecting box (e) at the end of the running rail (machine end), into which the filtered material is discharged. All the collecting boxes can be connected to a central suction system, which most practically leads to a pneumatic baling press.

7.2.5. Tracks

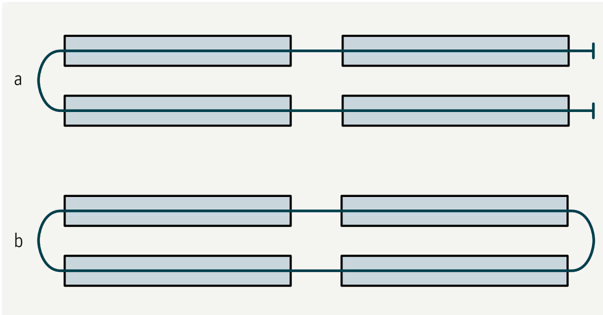


Fig. 71 – Track systems

In the case of individual units the traveling cleaner runs continuously back and forth over only one machine; in the case of collective units they can operate in either reciprocating (a) or rotary mode (b). The advantage of rotary mode is that the cleaner always passes the same position at the same interval, which is not possible in reciprocating mode. In reciprocating mode the blower cleans machine components that have just been cleaned when it reverses direction, whereas it takes a very long time for the blower to reach the machine at the other end of the track. Nevertheless, reciprocating mode is most frequently used because blowing occurs from different directions, in one pass from the right and in the next from the left, whereas in rotary mode the air jet always comes from the same side. There are many blind spots.

8. COMPACT SPINNING

8.1. Basic situation

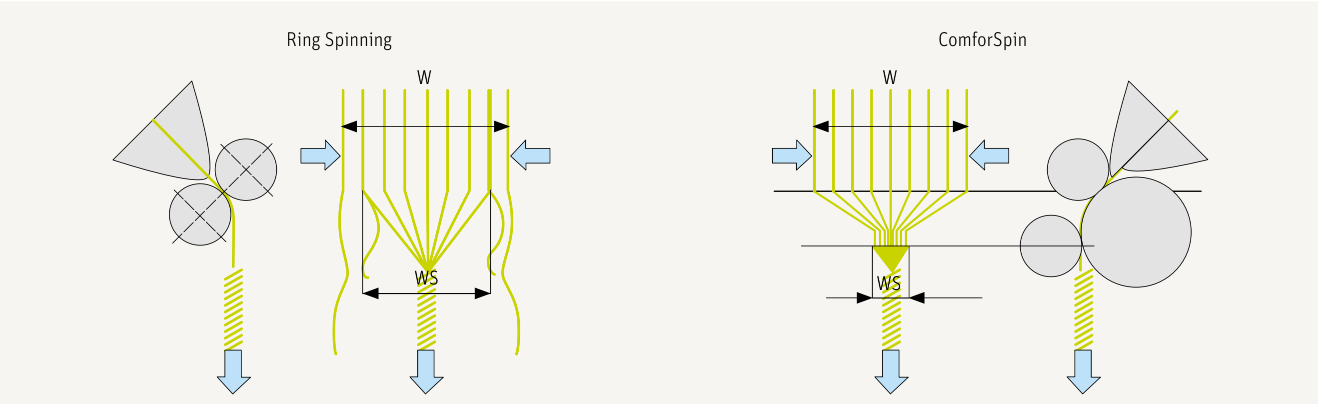


Fig. 72 – Conventional ring spinning vs. the ComforSpin principle

Despite the high degree of perfection of ring spinning, the ring spinning process has not yet achieved ideal performance. The schematic view of the yarn formation zone on the left in Fig. 72 illustrates the problem. The drafting system of a conventional ring spinning machine unfortunately delivers the fibers over a width W which is considerably larger than width WS of the adjacent spinning triangle (see also Fig. 84). This means that some edge fibers are lost or attached in a disorderly configuration to the yarn core already twisted. In other words, today's ring yarns have a structure that is not nearly as ideal as might be supposed.

8.2. Solution to the problem

To overcome this deficiency in the yarn formation process, Rieter pioneered the development of a compact spinning system, the so-called ComforSpin system. The working principle and the advantages of compact spinning will be explained below on the basis of the ComforSpin system. Fiber flow is laterally condensed by gentle aerodynamic forces in an aerodynamic condensing zone between the drafting unit and the yarn formation point. The effect of this procedure is shown schematically on the right in Fig. 72. The fiber flow reaching the spinning triangle is so narrow that the spinning triangle shrinks to almost zero and thus all fibers are caught by the spinning triangle and fully integrated into the yarn structure. This enables perfect yarn formation to be achieved.

8.3. Implementation of the basic solution

The implementation of the condensing zone in the Rieter ComforSpin machine is shown in Fig. 73. The fibers are supported and transported by a perforated drum. Inside this drum is a stationary insert with specially shaped openings. The air flow through the perforated drum, caused by subatmospheric pressure inside the drum, produces the desired condensation of the fiber flow prior to yarn formation, which takes place after the second top roller on the perforated drum.

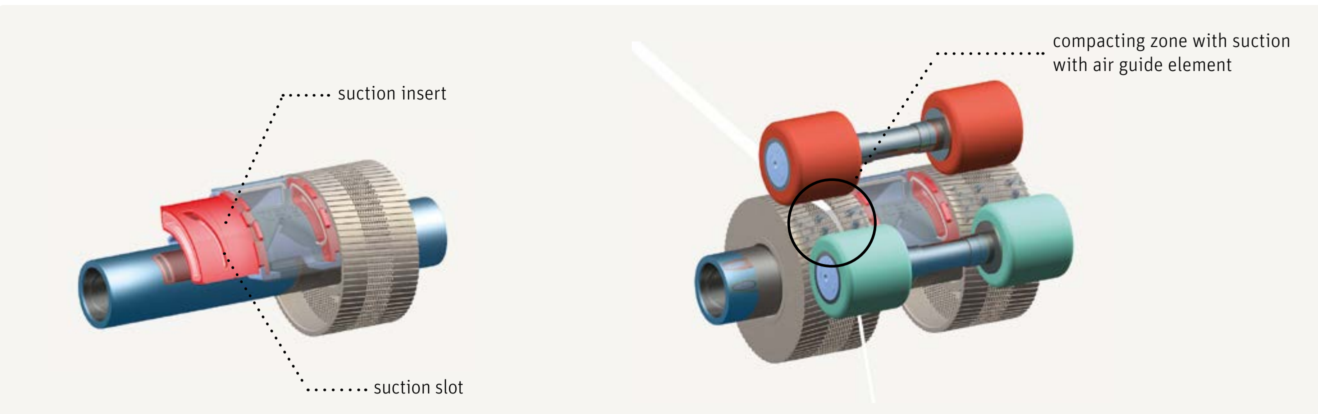
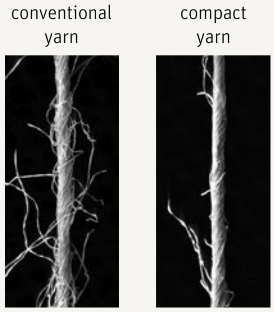


Fig. 73 – Suction system



- Low hairiness
- Higher strength and elongation
- Less fiber fly
- Significant advantages in downstream processing

Fig. 74 – Yarn comparison

This condensing device enables yarns with dramatically improved, virtually perfect yarn structure to be produced (Fig. 74). It is obvious that such an improved yarn structure has a very positive influence on yarn properties.

8.4. Advantages of condensing

First of all, the strength and elongation of the yarns are clearly improved. In addition, variations in strength and elongation values are reduced, resulting in considerably smaller numbers of weak places in the yarn.

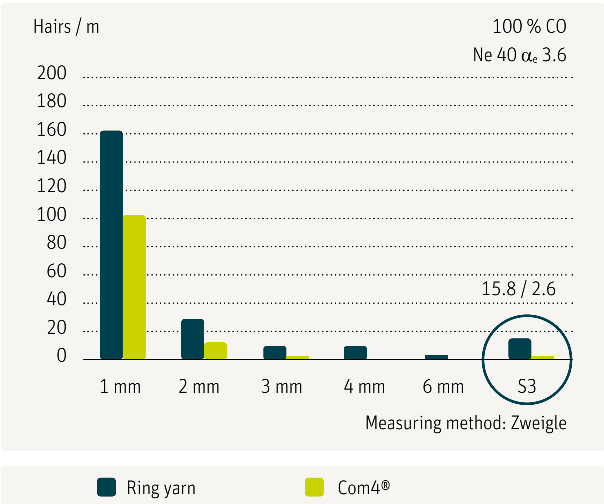


Fig. 75 – Hairiness S3 is decisive in downstream processing

Furthermore, the condensing process enables yarn hairiness to be reduced quite dramatically, especially of hairs longer than 2 mm (Fig. 75), i.e. those hairs which cause the main problems in downstream processing.
The condensing process also enables the abrasion resistance of the yarns to be improved. This not only results in much better yarn abrasion test values, but also considerably reduces deterioration in yarn quality during winding. All these quality advantages can be exploited by spinning mill operators. In most cases even yarn twist can be reduced, resulting in higher delivery speeds on the spinning machine. The excellent properties of compact spinning yarns (the brand name for yarns produced on the ComforSpin system is Com4® yarn) are, of course, also of advantage in downstream processing, as described below.

The lower hairiness and improved yarn abrasion resistance reduce the production of fly in weaving and knitting (Fig. 76 shows the situation in knitting), which in turn reduces the number of fabric defects and increases machine efficiency.

Lower hairiness and improved yarn abrasion resistance also enable the degree of sizing in weaving to be reduced by up to 50 % (Fig. 77). This not only results in economies in weaving, but also to a considerably improvement in the ecological situation.

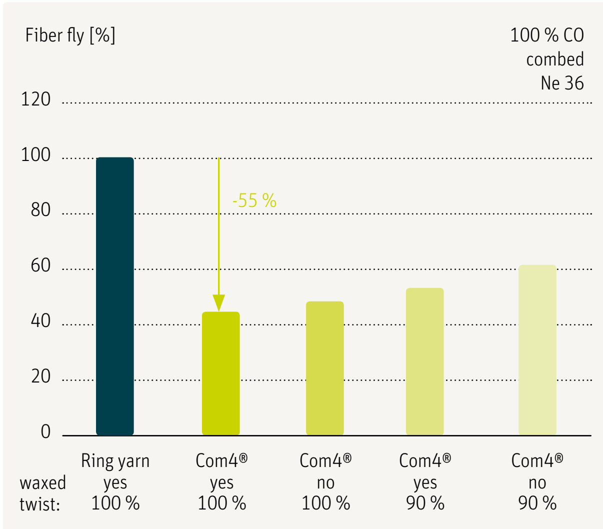


Fig. 76 – Com4® in knitting – lower fiber fly and fewer foreign fibers

Fig. 77 – Higher efficiency despite applying less size

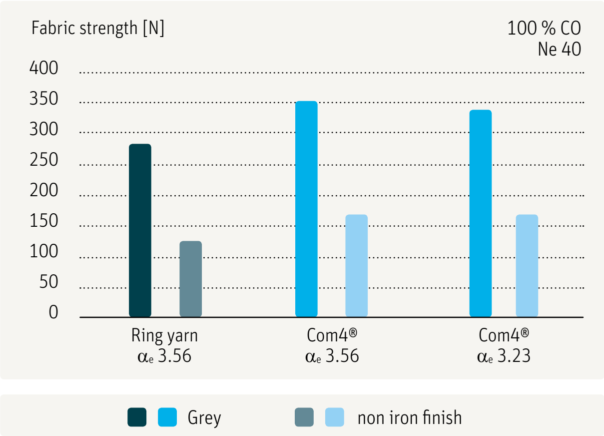


Fig. 78 – Fabric strength (warp) 09

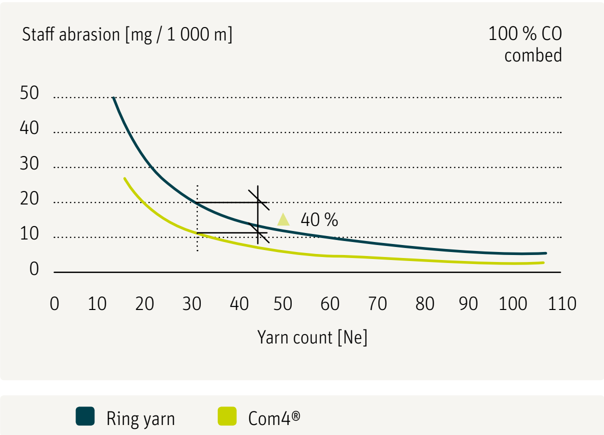


Fig. 79 – Lower abrasion in the Staff test

The improved properties of compact yarns are apparent right through to the fabric. As can be seen from Fig. 78 and Fig. 79 the mechanical fabric properties, i.e. fabric strength, abrasion resistance and pilling behavior, are clearly improved.

The better yarn structure can even be detected in the fabrics (Fig. 80). This results in more attractive luster of the fabrics and a softer hand. With compact yarn, the fabric hand can be made even softer by using a lower yarn twist level. With all these advantages, compact spinning has set a new standard, which is bringing positive changes in all stages of textile manufacturing, from spinning right up to the end product.

Based on the success of the ComforSpin system, other machinery manufacturers (Fig. 81, Suessen, Zinser, Toyota...) have developed their own compacting systems, also applying the aerodynamic principle.
Compact spinning is therefore much more than a niche system. Compact spinning is very successful for spinning high-quality yarns for a wide range of applications.

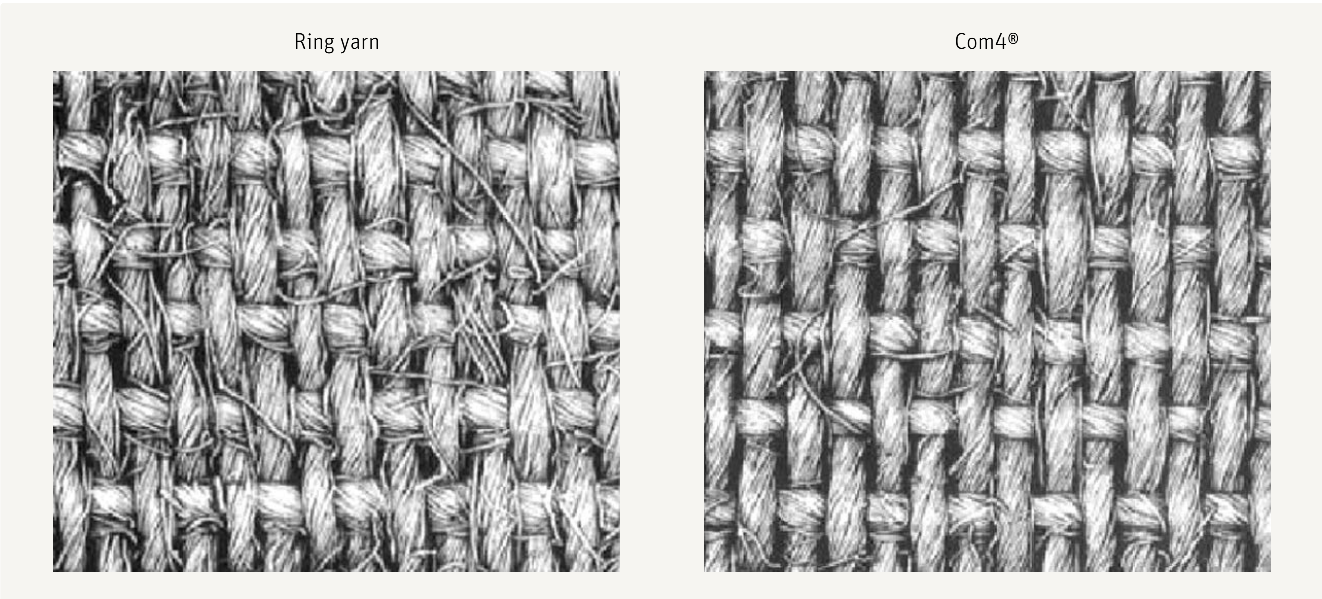


Fig. 80 – Result in the fabric

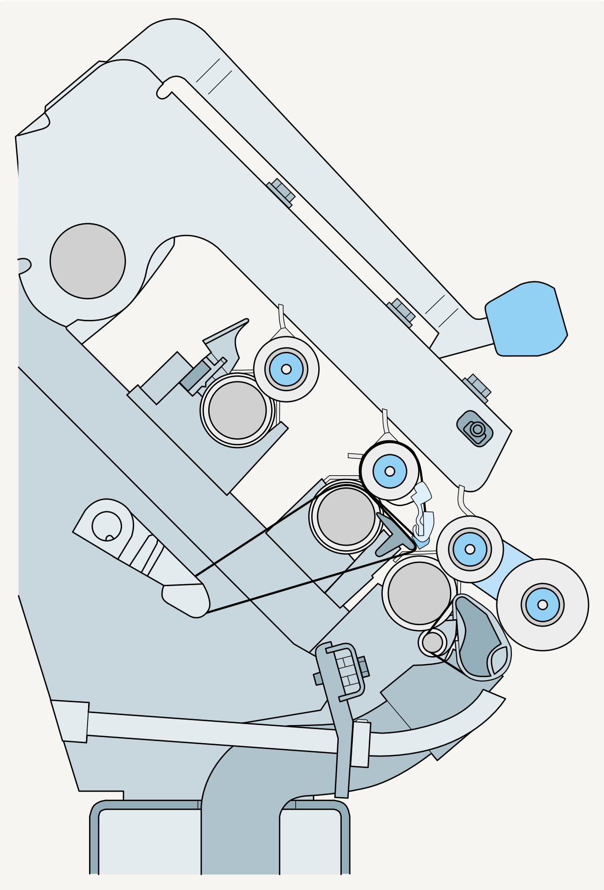


Fig. 81 – ELITE system by Suessen

9. TECHNOLOGICAL ADDENDA

9.1. Spinning geometry

9.1.1. Terms

The fiber bundle passes through the drafting system, the yarn guide eyelet, the balloon checking ring and the ring traveler on the way from the roving bobbin to the cop. These devices are arranged at different angles and distances relative to each other, which results in different angles of deflection and paths. Dimensions and guide angles, known collectively as spinning geometry, have a significant influence on the spinning process and final yarn quality, and especially on:

- tension conditions;
- ends down frequencies;
- irregularity;
- fiber integration;
- yarn hairiness;
- incidence of fly;
- etc.

Spinning geometry is therefore a very important optimization criterion for machinery manufacturers. However, it has to be borne in mind here that changing a spinning geometry parameter inevitably entails a change in all other geometry parameters.
Only the three most important factors from among the numerous spinning geometry parameters are dealt with in this volume, for reasons of space (Fig. 82). Other relationships are described in Volume 1. These parameters are:

- spinning triangle (W/WS);
- spinning length (L_1/L_2);
- spinning angle (γ).

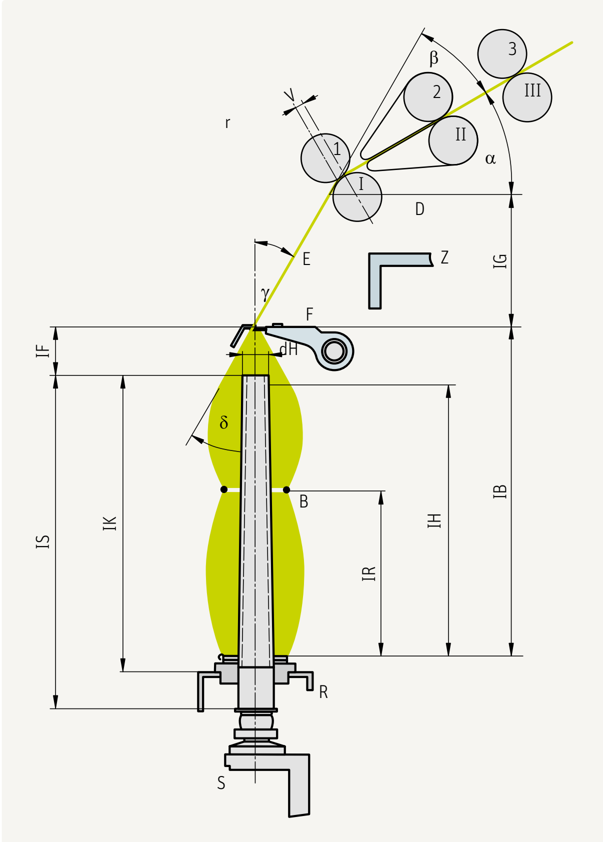


Fig. 82 – Spinning geometry angles and dimensions

Captions for Fig. 82:

D	Drafting system
Z	Cylinder support
E	Spinning path
F	Yarn guide eyelet
B	Balloon checking ring
R	Ring rail
S	Spindle
α	Angle of drafting system relative to horizontal
β	Angle of drafting system relative to spinning path axis
γ	Angle of the thread on the spinning path relative to the vertical
δ	Angle of the leg of the thread balloon relative to the spindle axis
lB	Balloon height (variable)
lG	Distance between drafting system and thread guide eyelet (variable)
lF	Distance between thread guide eyelet and top of spindle or tube (variable)
lS	Spindle height
lK	Tube height
lH	Traverse height of the ring rail (winding height)
lR	Distance between ring and balloon checking ring (variable)
dH	Outside diameter of the tube at the top
V	Overhang of the top front roller relative to the bottom roller

9.1.2. The spinning triangle

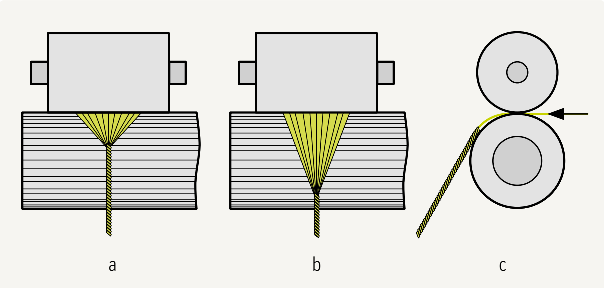


Fig. 83 – Short (a) and long (b) spinning triangle, (c) side view

9.1.2.1. The formation of the spinning triangle

The turns of twist in a yarn are generated at the traveler and move contrary to the direction of yarn movement toward the drafting system. Twist should run back as far as possible toward the nip line of the rollers, but it never reaches as far as the nip because, after leaving the rollers, the fibers first have to be diverted inwards and wrapped around each other. The twist moves up until angle κ (which is the angle of the fiber arrangement in the yarn) is equal to angle η of the spinning triangle (Fig. 84). There is therefore always a triangular bundle of fibers without twist, the so-called spinning triangle, at the exit from the rollers. By far the most end breaks originate at this weak point, because the yarn tension in the balloon can be transmitted almost without obstruction as far as the drafting system, whereas twist in the spinning triangle is zero.

9.1.2.2. The dimensions of the spinning triangle (width and length)

(see also: W. Klein, Spinning Geometry and its Significance, International Textile Bulletin, Zurich, 1993)
The dimensions of the triangle and their influence on spinning are derived hereafter by some statements in an uncomplicated scheme, starting with the width of the triangle.

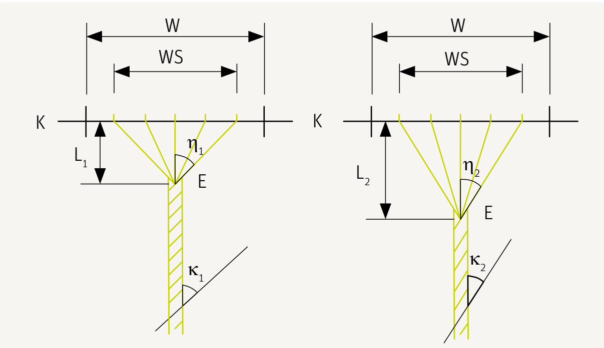


Fig. 84 – Spinning triangle – influence of the twist

With a given outlet width of W, length (L) of the spinning triangle determines in turn the spinning width (WS), which – unfortunately – is always smaller than W. Due to the difference between W and WS, the edge fibers leaving the drafting system are not caught by the spinning triangle and therefore not incorporated into the yarn. These fibers are lost by forming fly and fluff or they are attached to the outside of the yarn already formed in an uncontrolled manner, thus increasing hairiness. The greater the difference between W and WS, the higher the loss of fibers, the greater the hairiness, and also the adverse impact on yarn structure. Width WS should therefore be as close as possible to W.
On the other hand, the length of the spinning triangle depends mainly on the twist according to the following correlation: since twist always rises to a state where tie-in angle η at tie-in point E and fiber disposition angle κ in the yarn are equal, high yarn twist results in a short (L_1), but low yarn twist in a longer spinning triangle (L_2). This means that the greater length (L_2) increases the size of the "spinning triangle" weak point and thus the ends down rate. To keep the ends down rate at the same level as for high-twist yarns, the yarn manufacturer is forced to reduce yarn tension by lowering spindle speed (e.g. when spinning knitting yarns).

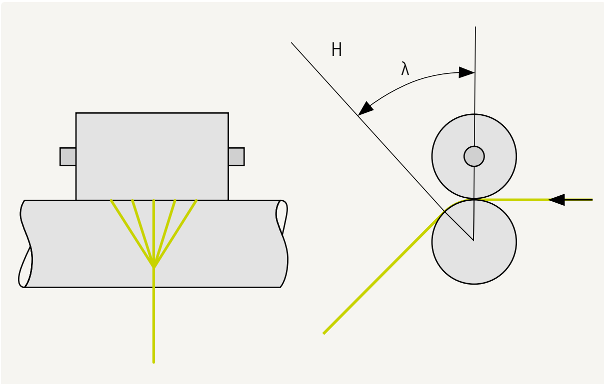


Fig. 85 – Reflection arc at the front roller

Not only yarn twist but also machine design affects the length of the spinning triangle through wrapping angle λ (Fig. 85) of the fiber strand at the front roller. The wider this angle, the longer the spinning triangle with all its advantages and disadvantages. However, two additional advantages of the deflection at the front roller are worth mentioning; firstly the extra guidance of the fibers by supporting the fibers without clamping them, and secondly the reduction of the abrupt bending-off of the edge fibers. Being supported over a small surface area at the front roller up to lift-off line H, the fibers are gathered-in curving from the edge and tied in firmly and regularly. Fiber loss is also reduced (Fig. 86).

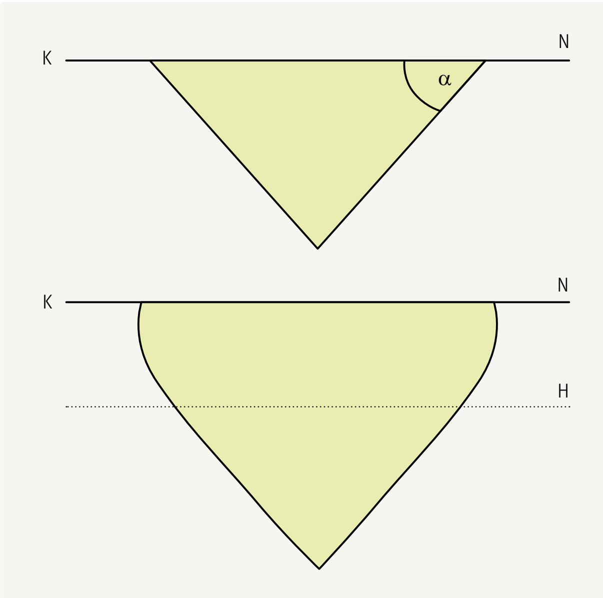


Fig. 86 – Spinning triangle delivery angle of the fibers

Of course, when discussing the advantages of a longer spinning triangle it is always assumed that most of the fibers in the fiber strand are longer than the spinning triangle. This is mostly the case, as the length of the spinning triangle varies according to the machine design (inclination of the drafting system α, height IG between lappet F and front roller etc.) of different manufacturers in a range between 2.5 and 7 mm only (Fig. 82).

9.1.2.3. Influence on the ends down rate

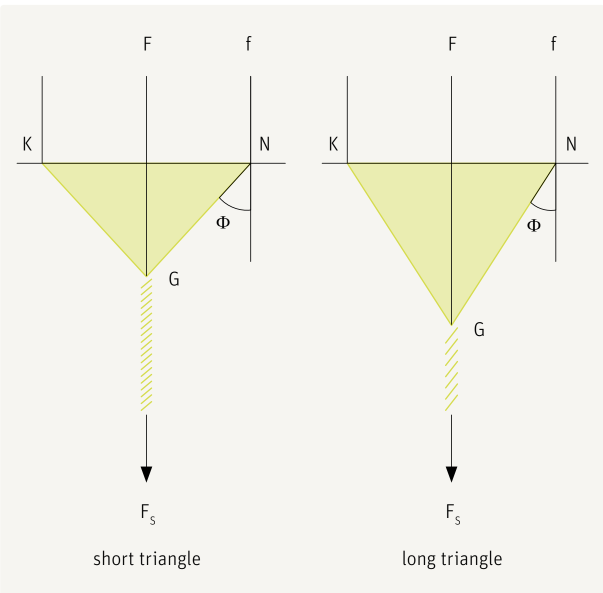


Fig. 87 – Length of the spinning triangle

This reasoning is based on a comparison of a short triangle (Fig. 87, left) and a longer one (Fig. 87, right), and on the behavior of two fibers (F in the middle and f at the edge of the triangle).
Both fibers are longer than the spinning triangle (distance K/N to G). Whereas fiber F undergoes no change in direction of movement during its passage through the spinning triangle, fiber f is bent to a greater or lesser extent at N (angle Φ), increasing distance N - G. Consequently, the tension forces from the yarn cause an elongation of fiber f. So if bending angle Φ is large (for short spinning triangles), the elongation of fiber f is very high. That is why the tension forces (Fig. 87, F_S) of the yarn during the formation of the yarn pass mainly into edge fibers f (in zone Z_S, Fig. 88, left). Fibers F in the core remain almost free of elongation and hence of tension.

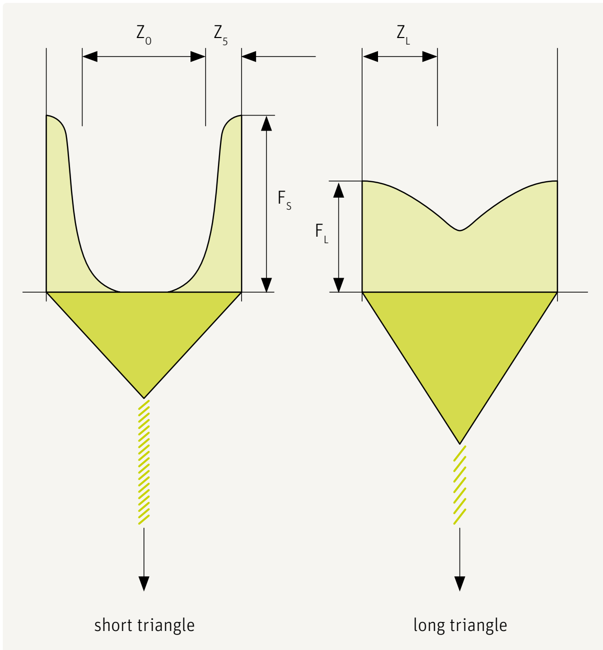


Fig. 88 – Spinning triangle – forces acting on the fibers:
short staple triangle; long staple triangle

Therefore almost the entire tension force of the yarn in the balloon acts only on a certain part of the fibers in the spinning triangle, i.e. on the edge fibers. As a result, when tension peaks due to shocks or uneven running from traveler or balloon act on the spinning triangle, these few fibers cannot bear the full load; they break or the fiber strand slips apart, causing an end break. That is why end breaks normally occur within the spinning triangle from outside (edge) to inside (core). This danger is always present with a short spinning triangle. Owing to the large angle ϕ, the tensile forces are distributed very unevenly; high on the edge fibers (zone Z_S) and much less on the central fibers (zone Z_O). Distribution is much better (zones Z_L) with a long triangle. As a result it can be stated that spinning conditions are improved by reducing angle ϕ. A long spinning triangle therefore shows a more uniform distribution of forces (Z_L). Since tension is distributed over the entire fiber mass in these conditions, fewer end breaks are the obvious result.

9.1.2.4. Influence on the yarn structure

Yarn formation takes place in the spinning triangle. If the yarn is to have high strength, high elongation and regularity combined with low neppiness and hairiness, the fibers in the yarn must be:

- well oriented
- evenly distributed in length and cross-section
- wound spirally around the axis, and
- all fibers must be tied in under tension.

Of all the spinning systems available or known, these requirements are best satisfied by ring spinning, especially with regard to the last, very important item. However, this holds true only in conjunction with good spinning geometry, i.e. with an optimal spinning triangle. If it is too short, core fibers (F) will be tied in without tension. They can then absorb tensile forces in the axial direction only to a limited extent, or only after the fibers in the outer layer (f) have been broken. Since the distribution of tension forces in the final yarn is similarly uneven to that in the spinning triangle, the yarn shows the same effect. When stress is applied to the yarn, the edge fibers undergo so much elongation from the very beginning that the forces acting on them either cause the fibers to break, or in some cases to slide apart before the loading forces can act on the neighboring fibers inside the yarn. Fiber breaks proceed successively from outside to inside. The yarn has low strength. Since the twist inserted in the yarn is insufficient due to the uneven distribution of tension (the edge fibers are ultimately wrapped around the core fibers), the negative effect is reinforced. The yarn structure falls short of the optimum, and most of the yarn quality parameters suffer more or less.

9.1.2.5. Concluding remarks on the spinning triangle

One further remark is required when summarizing the entire reasoning behind the spinning triangle. Experts generally discuss what happens at the spinning triangle by concentrating on the length of the triangle, although the main influencing factors are in fact the angles, as is shown by this investigation. However, since these angles mainly depend on the length and vice versa, this simplification is admissible and is used here, too. Using length as the criterion, it can be stated that long as well as short spinning triangles have their advantages and disadvantages. Long spinning triangles might increase the ends down rate by enlarging the "spinning triangle" weak point and increase hairiness, since the hairiness of the yarn also depends to a great extent on the area of the spinning triangle. On the other hand, a short spinning triangle also results in an increase in hairiness and fly accumulation as well as a reduction in yarn strength due to the difficulties in tying in the edge fibers, and due to irregular distribution of fiber tension in the yarn structure. The latter is also responsible for an increase in the ends down rate. As is nearly always the case in spinning, the problem is to find the optimum balance. It is therefore evident that as long as a significant spinning triangle exists, perfect yarn structure with excellent spinning performance cannot be achieved. In order to improve yarn quality and spinning performance significantly, it is necessary to find ways to reduce the size of the spinning triangle drastically, and above all to reduce the width of the fiber flow W exactly to the width of the remaining spinning triangle. This has been achieved by so-called compact spinning systems (see chapter 8).

9.1.3. Spinning length E

This length E (Fig. 82) differs quite markedly depending on machine design. If it is very long, then a second or even third balloon might emerge between lappet (F) and the front roller, in extreme cases increasing the ends down rate. However, insufficient length is much more troublesome, because the spinning length is a damping zone for all the shocks and disturbances coming from the balloon. If they pass without reduction into the spinning triangle, they cause a considerable increase in ends down rates. Here too, an optimum has to be found.

9.1.4. Spinning angle γ

At the thread guide of the lappet, the yarn is deflected more or less according to the design of the machine, mainly depending on angle γ (Fig. 82). This angle also has a major influence on the ends down rate and yarn formation due to the twist insertion operation. Twist is inserted at the traveler by its rotation. The twist must rise against the movement of the yarn up to the front rollers, where it has to tie in the fibers. If deflection arc γ at the lappet is large (Fig. 82), a substantial part of the rising twist will be held back at this point. The fiber mass at the critical point, i.e. the tying-in point of the spinning triangle, therefore has less twist than ultimately the final yarn. This results firstly in more ends down, because yarn strength between the drafting system and the lappet is simply inadequate owing to insufficient twist, and secondly the twist retention impairs the tying-in of the fibers. The yarn receives its twist in two stages, most of it at the spinning triangle and then an additional twist insertion in a yarn already formed between traveler and lap-

pet. This in turn is detrimental to the yarn properties.
Also important at this point is almost constant contact with the thread guide eyelet, i.e. the yarn should always lie on the lappet wire. Alternate touching and lifting clear of the wire during one revolution of the traveler causes tension peaks at the spinning triangle which again increase the ends down rate.

9.1.5. Roller overhang

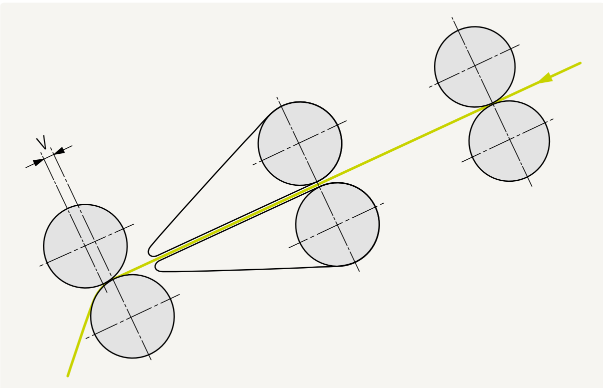


Fig. 89 – Overhang (V) of the top front roller

The top front roller almost never lies vertically above the associated bottom roller. Usually, the top roller is shifted about 2 to 4 mm (V, Fig. 89) forward. This gives somewhat smoother running, because the weighting force exerts a stabilizing effect acting in the running direction, thus preventing oscillation of the top roller. Furthermore, the angle of wrap is reduced and the spinning triangle is made shorter. The overhang must not be too large, however, otherwise the distance from the exit opening of the aprons to the roller nip line becomes too long, resulting in poorer fiber guidance and increased irregularity.

9.1.6. Other dimensions in spinning geometry

Balloon height lB (Fig. 82):
Every spinner is interested in producing large packages to increase their running time on subsequent machines, at least as long as the large package does not influence productivity. As cop size is a function of ring diameter and tube length (lK), choosing large dimensions in both might be considered. However, this is not possible because the larger the ring diameter the lower the production rate, and tube length depends on ring diameter. If the tube is too long, the balloon becomes too high for its diameter and this implies considerable tension differences between winding on the cop base and winding at the top. Even when using balloon checking rings, as is mostly the case, a balloon of this shape is unstable. It might – and in fact often does – collapse, leading to ends down.The ratio of ring diameter to tube length should be about 0.2 to 0.225.

Lift lH:
About 20 mm shorter than tube length lK.

Distance from top of tube to thread guide (lappet) (lF):
At least 2 x dH + 5 mm.

Basic setting lR (distance from ring to balloon checking ring):
Slightly less than half length lB.

Ratio of tube outside diameter at top to ring diameter:
About 0.45 to 0.5.

9.2. Quality standards

9.2.1. A new approach to quality

Quality is very often still regarded as something absolute, i.e. the maximum is the target. This is a completely wrong approach, as quality will more than ever become something relative: it has to be tailored exactly to requirements and no more. Any excess quality (compared to requirements) represents cash lost for the producer. It rapidly drives a company into the red. Going forward, the textile industry has to create a new approach to quality in the mill, changing from a mentality of maximum quality to a mentality of engineered and optimized quality that is assured absolutely and long-term. Engineered and optimized quality in this context means that the quality is tailored exactly to demands in terms of:

9.2.1.1. Dimensioned quality

Fulfilling demands but no more.
Today only very few mills produce this „dimensioned quality". Since the majority are not aware of the exact demands specified for the product, through their own fault or that of the customer, they usually seek to achieve a peak, becoming better and better month by month, thus producing so-called:

9.2.1.2. Overdimensioned quality

An irresponsible waste of resources and money.
Another very common outcome is the production of underdimensioned quality.

9.2.1.3. Underdimensioned quality

These products are mostly cheap but of low value. The problem is very often not an inadequate average standard, but the permanent occurrence of reductions in quality, rendering the product useless for certain applications. What matters, therefore, is to reach quality agreements with the customer, enabling the producer to work out his product specifications and to tailor quality exactly according to the specified demands. The aim should be:

9.2.1.4. Quality that is as good as required
(and not as good as possible)

Uster Statistics might initially provide assistance in finding a basis for agreement. However, it should be borne in mind that these figures, while very good and very valuable tools for comparison and adjustment, can never replace agreements between producer and customer. Working only according to comparative Uster figures mostly means producing overdimensioned quality.

9.2.2. Quality standards according to Uster Statistics

However, since Uster Statistics are a very important controlling tool for mills, and will continue to be for a long time, the most widely used quality parameters for yarn, according to the state of the art in 2007, are shown on the following pages. (By courtesy of the Zellweger Company in Uster, Switzerland)

These parameters are:
- mass variation (CV)
- imperfections (thin places, thick places, neps)
- strength (breaking tenacity)

for
- carded and combed cotton yarns on packages (not cops)
- blended yarns: PES/cotton (combed), 65/35, 67/33, on packages.

For the other parameters see Uster Statistics 2007.

9.2.2.1. Mass variation

Fig. 90 – Mass variation CO, 100 %, carded, ring yarn, cone, weaving
Fig. 91 – Mass variation CO, 100 %, combed, ring yarn, cone, weaving
Fig. 92 – Mass variation PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone

9.2.2.2. Imperfections

Fig. 93 – Thin places CO, 100 %, carded, ring yarn, cone, weaving
Fig. 94 – Thick places CO, 100 %, carded, ring yarn, cone, weaving
Fig. 95 – Neps CO, 100 %, carded, ring yarn, cone, weaving
Fig. 96 – Thin places CO, 100 %, combed, ring yarn, cone, weaving
Fig. 97 – Thick places CO, 100 %, combed, ring yarn, cone, weaving
Fig. 98 – Neps CO, 100 %, combed, ring yarn, cone, weaving
Fig. 99 – Thin places PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone
Fig. 100 – Thick places PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone
Fig. 101 – Neps PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone

9.2.2.3. Tensile properties (breaking tenacity, at 5 m/min)

Fig. 102 – Tensile properties CO, 100 %, carded, ring yarn, cone, weaving
Fig. 103 – Tensile properties CO, 100 %, combed, ring yarn, cone, weaving
Fig. 104 – Tensile properties PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone

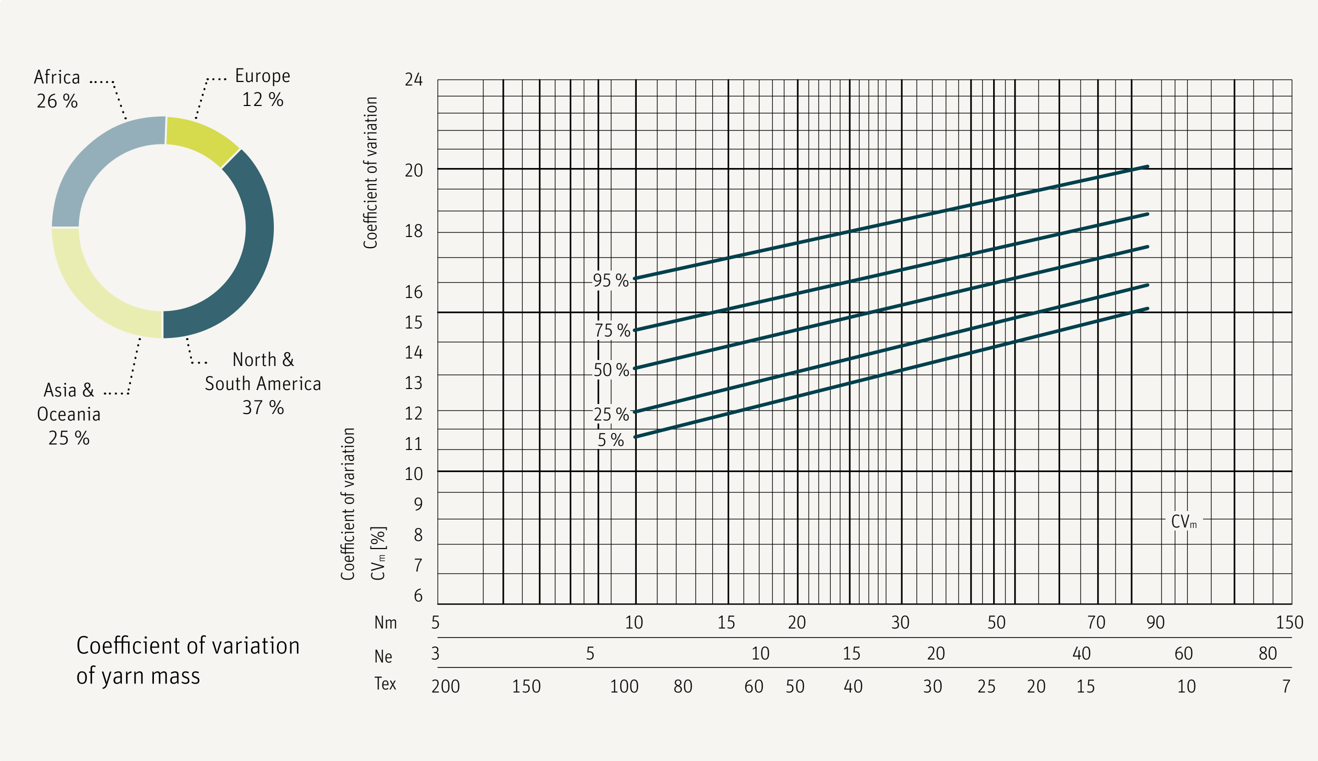


Fig. 90 – Mass variation CO, 100 %, carded, ring yarn, cone, weaving

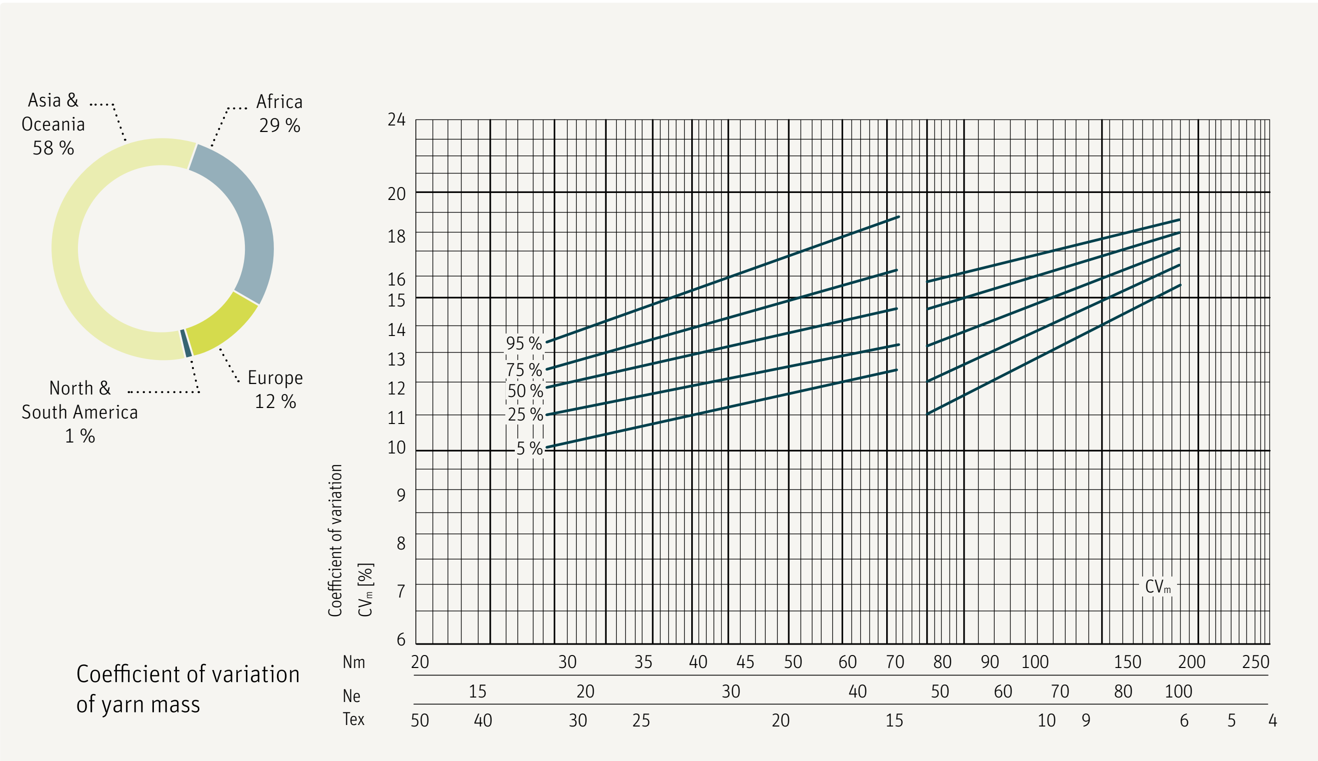


Fig. 91 – Mass variation CO, 100 %, combed, ring yarn, cone, weaving

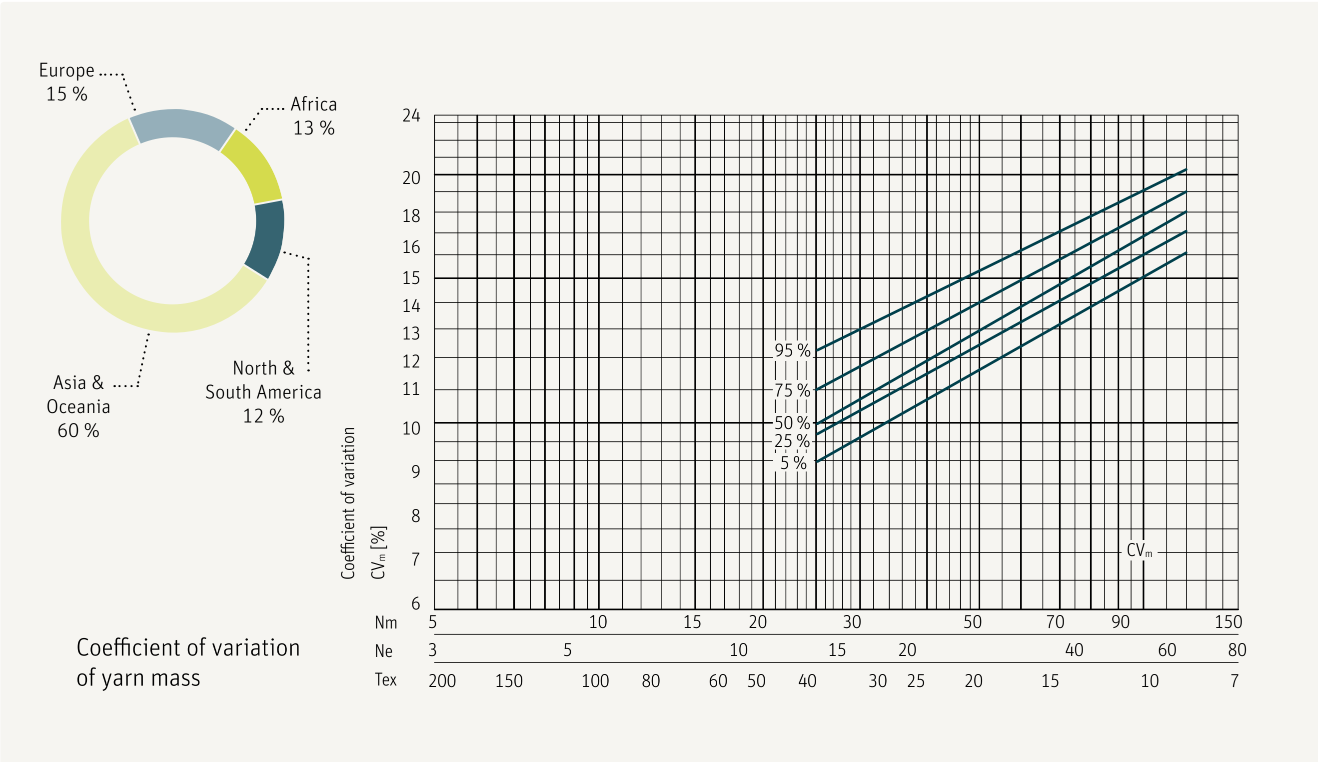


Fig. 92 – Mass variation PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone

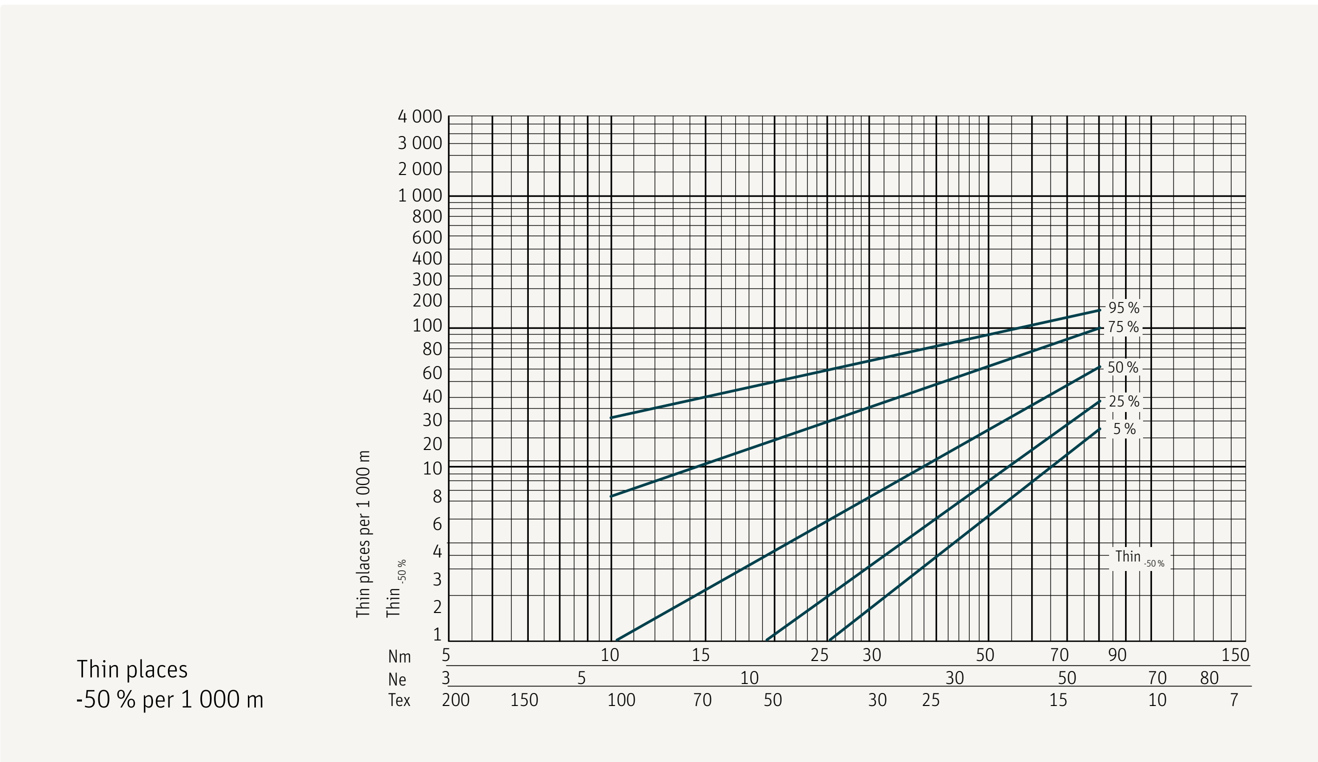


Fig. 93 – Thin places CO, 100 %, carded, ring yarn, cone, weaving

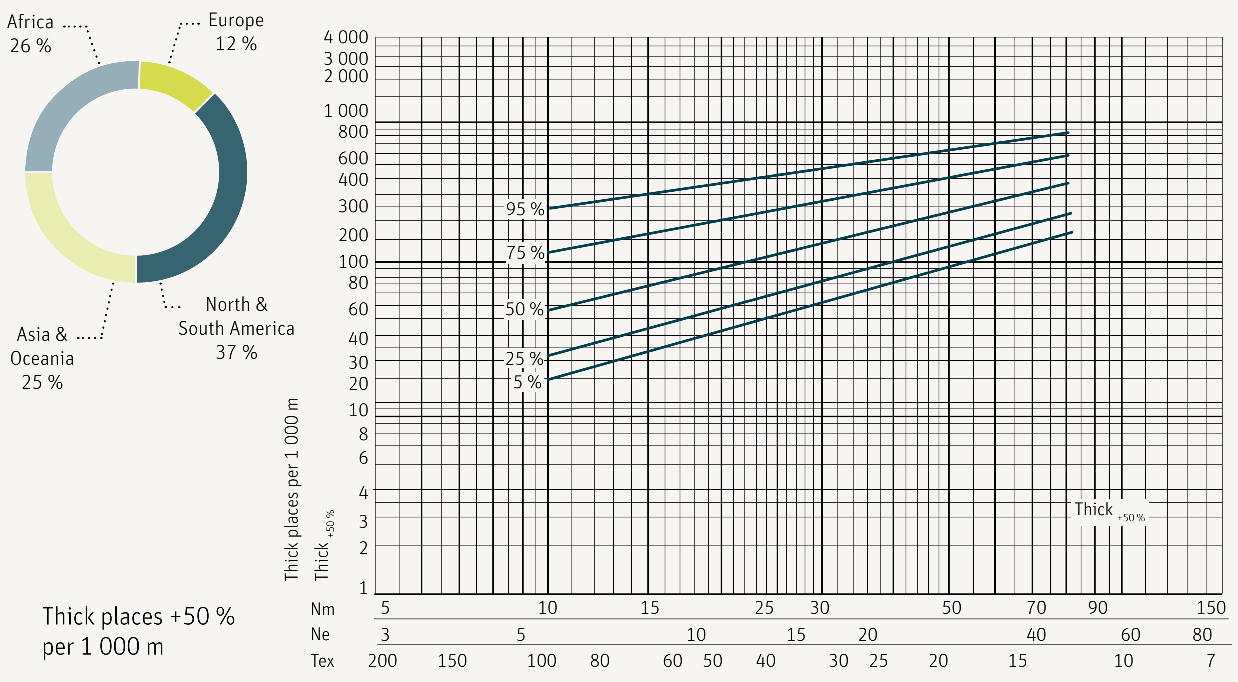


Fig. 94 – Thick places CO, 100 %, carded, ring yarn, cone, weaving

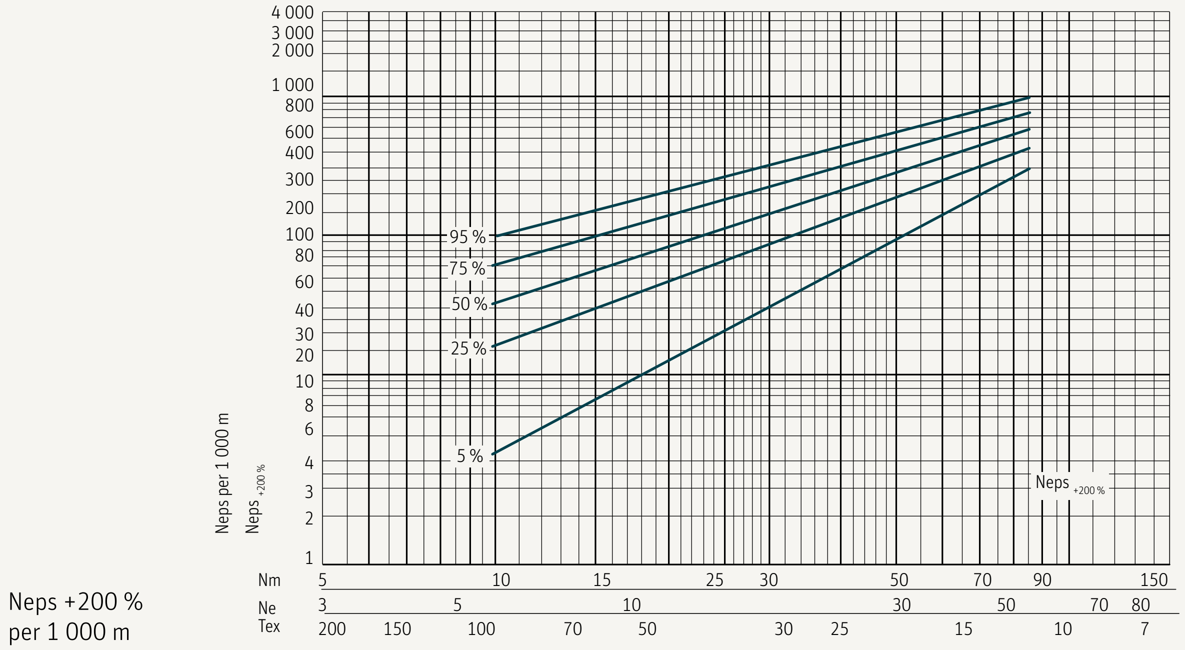


Fig. 95 – Neps CO, 100 %, carded, ring yarn, cone, weaving

Thin places -50 %
per 1 000 m

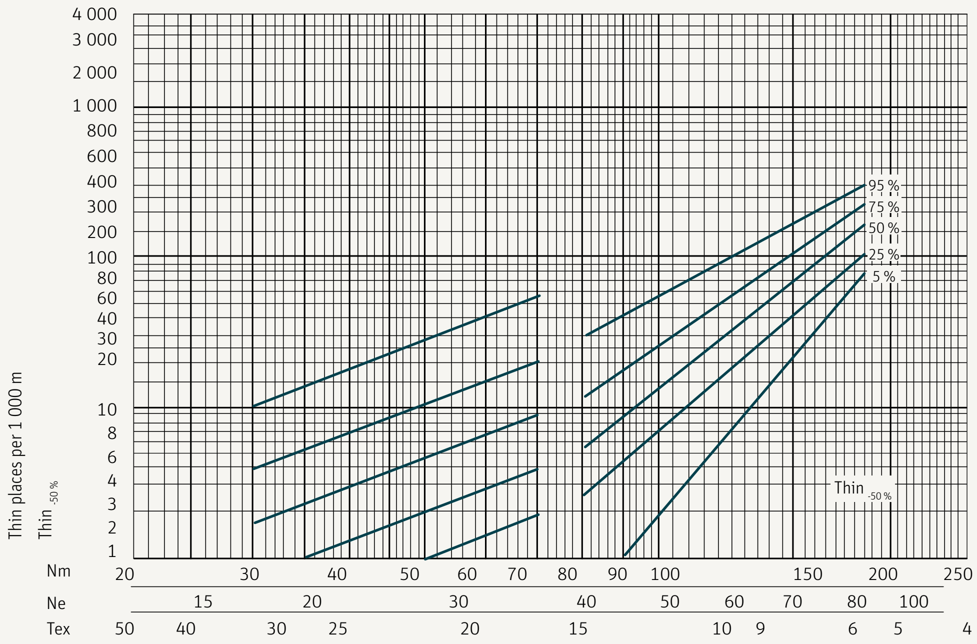
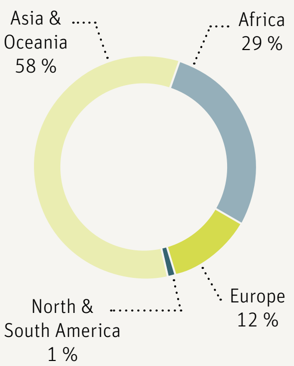


Fig. 96 – Thin places CO, 100 %, combed, ring yarn, cone, weaving



Thick places +50 %
per 1 000 m

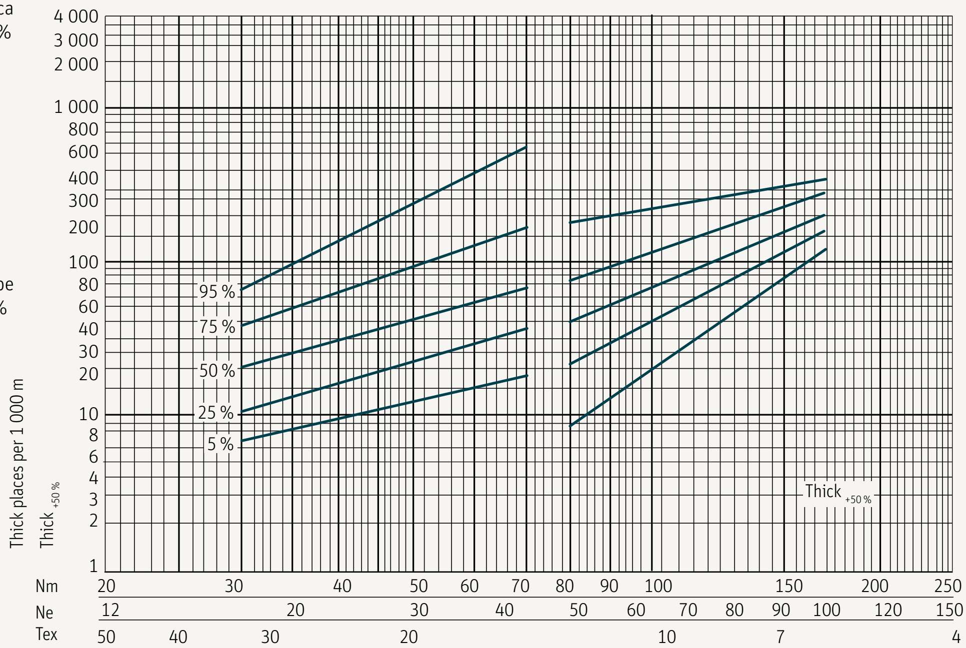


Fig. 97 – Thick places CO, 100 %, combed, ring yarn, cone, weaving

Neps +200 %
per 1 000 m

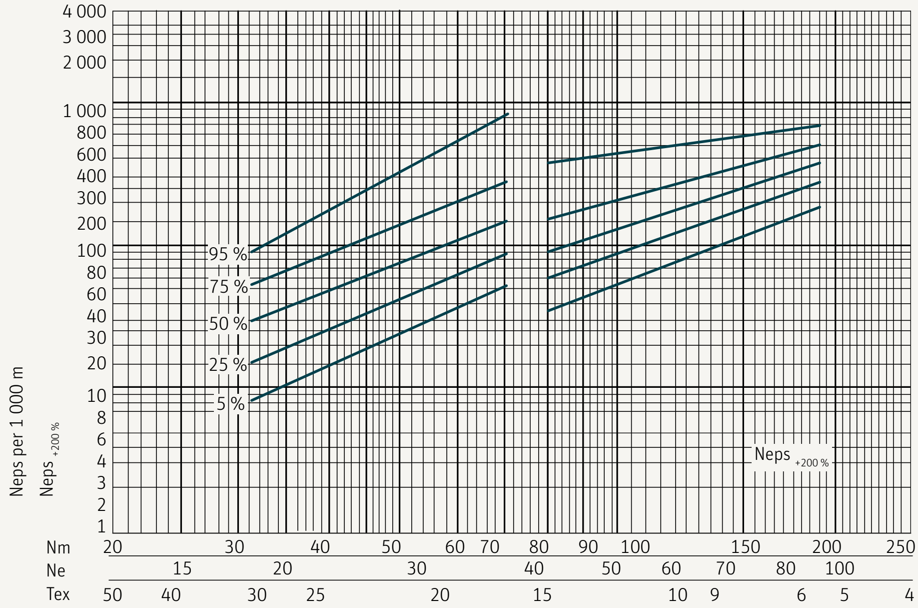


Fig. 98 – Neps CO, 100 %, combed, ring yarn, cone, weaving

Thin places -50 %
per 1 000 m

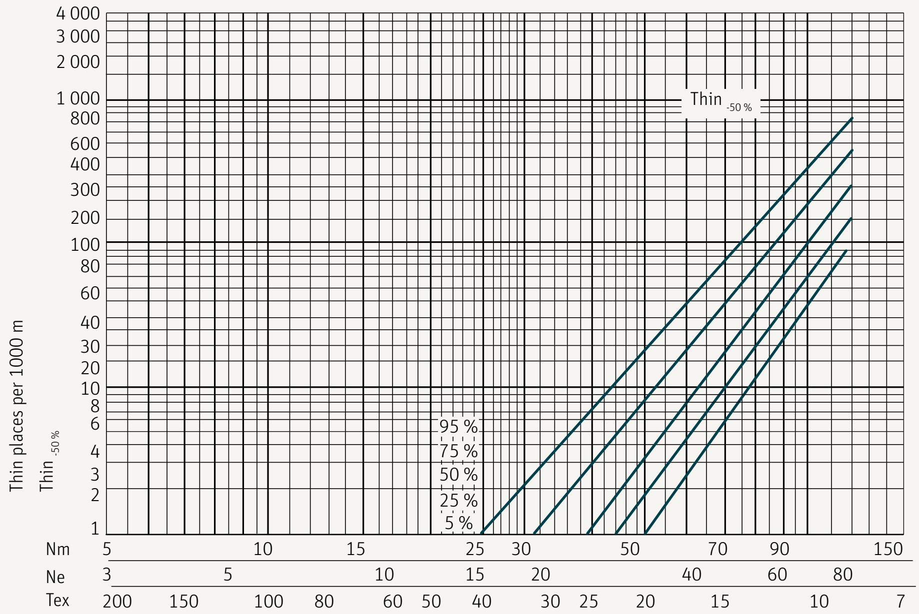
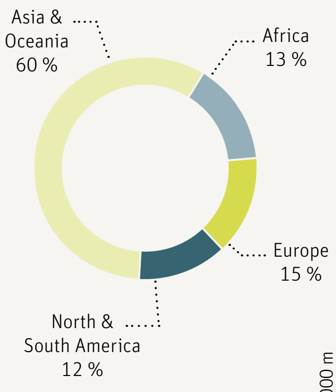
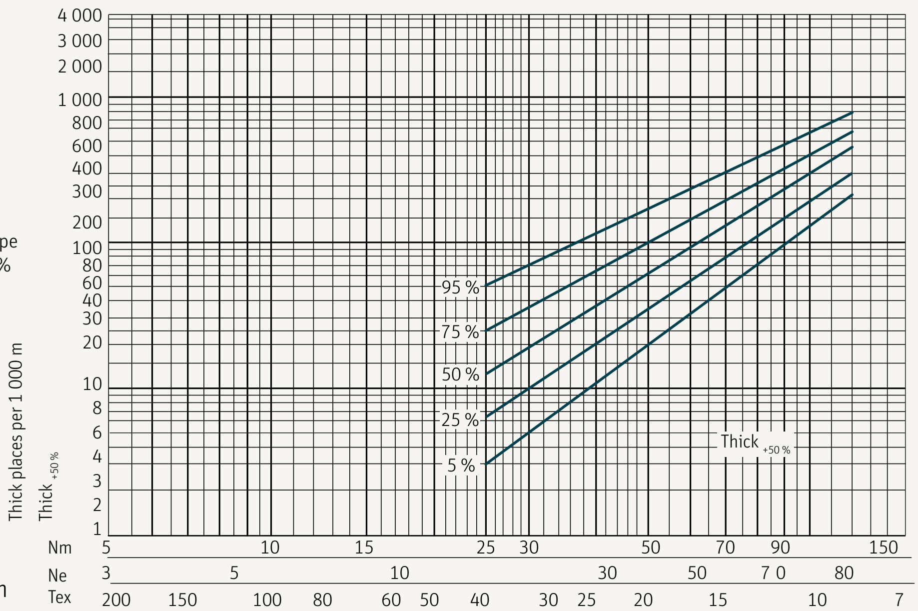


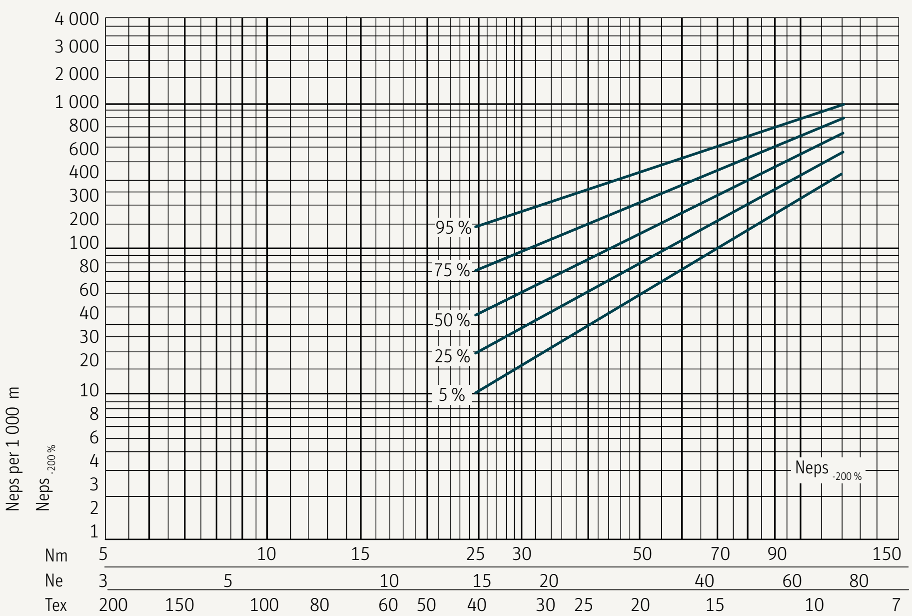
Fig. 99 – Thin places PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone





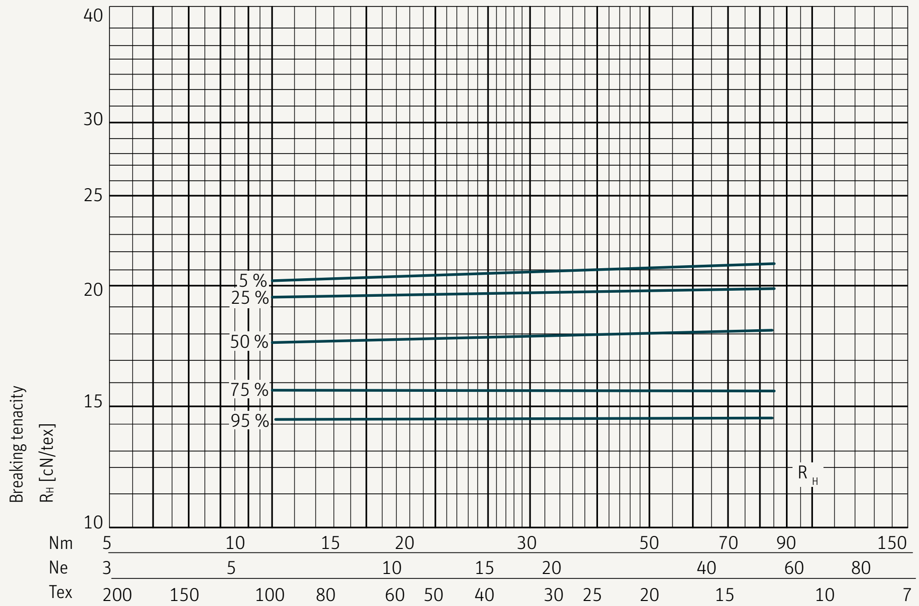
Thick places +50 % per 1 000 m

Fig. 100 – Thick places PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone



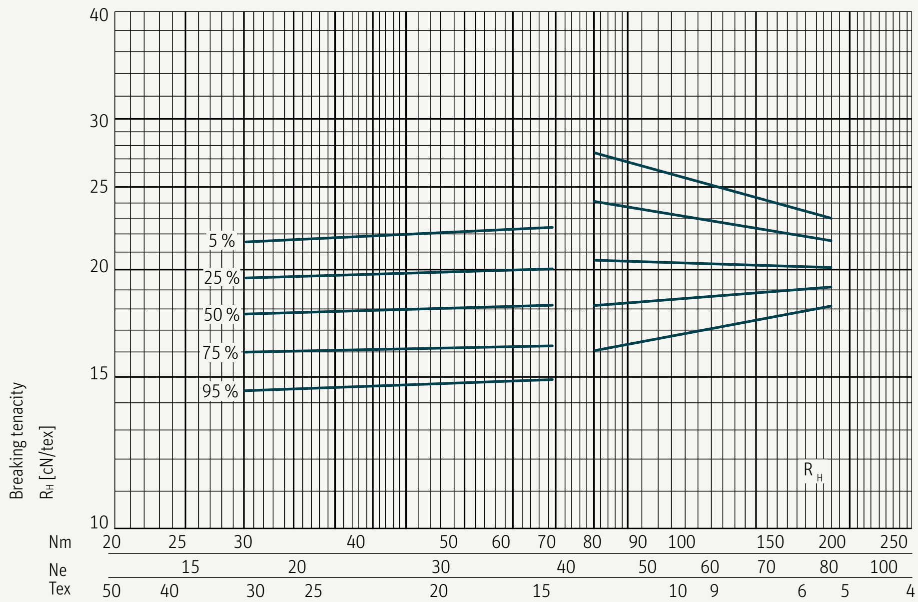
Neps +200 % per 1 000 m

Fig. 101 – Neps PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone



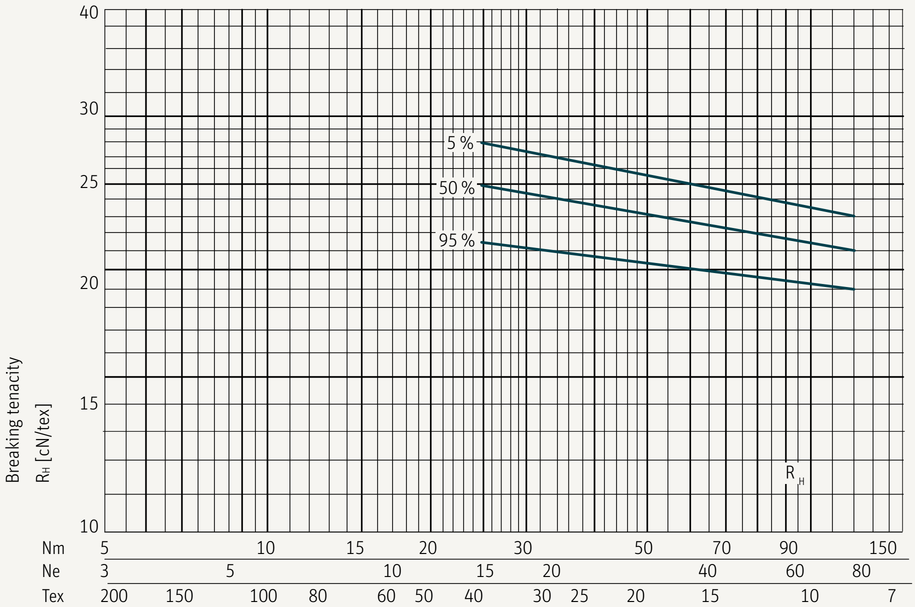
Breaking tenacity
(CRE, 5 m/min)

Fig. 102 – Tensile properties CO, 100 %, carded, ring yarn, cone, weaving



Breaking tenacity
(CRE, 5 m/min)

Fig. 103 – Tensile properties CO, 100 %, combed, ring yarn, cone, weaving



Breaking tenacity
(CRE, 5 m/min)

Fig. 104 – Tensile properties PES/CO, 67/33 % and 65/35 %, combed, ring yarn, cone

ILLUSTRATIONS

The Rieter Manual of Spinning

Volume 4 – Ring Spinning

The fourth volume covers the technical and technological aspects of ring spinning. This is a very important sub-field of yarn production, because the ring frame has a major influence on the yarn product and its quality. Ring-spun yarn still represents the absolute standard for comparison when evaluating yarns produced by other spinning processes.

Rieter Machine Works Ltd.
Klosterstrasse 20
CH-8406 Winterthur
T +41 52 208 7171
F +41 52 208 8320
machines@rieter.com
aftersales@rieter.com

Rieter India Private Ltd.
Gat No. 768/2, Village Wing
Shindewadi-Bhor Road
Taluka Khandala, District Satara
IN-Maharashtra 412 801
T +91 2169 304 141
F +91 2169 304 226

Rieter (China)
Textile Instruments Co., Ltd.
Shanghai Branch
Unit B-1, 6F, Building A,
Synnex International Park
1068 West Tianshan Road
CN-Shanghai 200335
T +86 21 6037 3333
F +86 21 6037 3399

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