TECHNICKÁ UNIVERZITA V LIBERCI
Fakulta textilní

Textile Engineering

Part: Spinning

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Yarn definition

YARN = a product of substantial length and relatively small cross-section consisting of staple fibres or filament(s) with or without twist

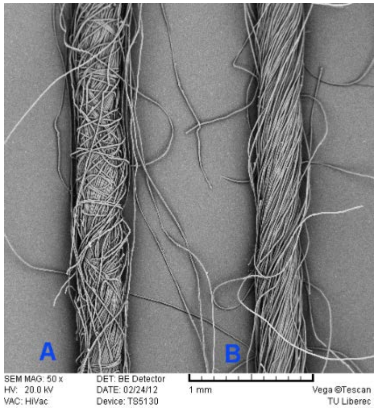
Continuous filament yarn

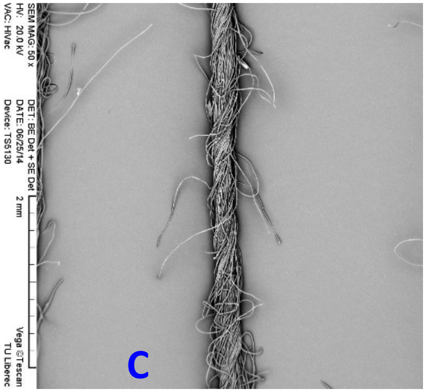
Yarn composed of one or more filament that run essentially the whole length of yarn.

- Monofilament yarn
- Multifilament yarn

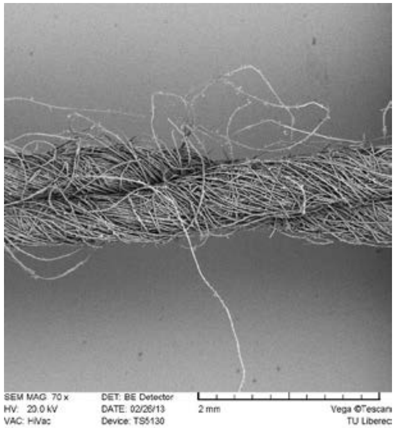
Microscopic image of multifilament yarn - 100% PES, 36 fibrils, 10 tex

STAPLE SPUN YARN: a longitudinal textile compound of spinnable fibres, strengthened with a twist or bonding such way that a lot of individual fibres break during the yarn breakage (by Czech definition):





Staple spun yarn – a) rotor spun yarn, b) ring spun yarn, c) air-jet spun yarn (Rieter)



Plied staple spun yarn

Yarn classification

Group	Sub-group	Examples
Continuous filament yarns Yarn composed of one or more filament that run essentially the whole length of yarn	**Un-textured (flat)**	**Twisted, Interlaced, Tape.**
	Textured	**False twisted, Stuffer box crimp** **Bi-component, Air-jet.**
Staple Spun Yarns	**Non-effect/Plain (Conventional)**	**Carded, Combed Ring Spun, Compact ring spun** **Worsted compact ring spun, conven. ring spun; Semi-worsted, Woolen,**
	Non-effect/Plain (Unconventional)	**Rotor, Air-jet, Vortex, Friction, Repco**
	Fiber blend	**Blend of two or more fiber types comprising non-effect yarn**
	Effect/fancy	**Fancy twisted, Hollow-spindle fancy yarn, Spun effects**
Composite Yarns	**Filament core** **Staple core**	**Core spun (filament or staple fibers forming core) and staple fibers as sheath**
Folded/Plied/Doubled	**Filament** **Staple**	**Two or more yarns twisted together**

The most important properties of yarn

Yarn Numbering Systems

- It is not the practice to set up a spinning machine to produce a specified yarn diameter. A more useful and practical measure that indirectly gives an indication of yarn thickness is a parameter that is termed the yarn count or yarn number

- **Yarn count** = The linear density - is defined as the mass per unit length.

- Direct system. This expresses the count as the mass of a standard length. The mass is measured in grams, and the specific length is either 1 km or 9 km.

  (tex, Tden)

- Indirect system. This gives the length that weighs a standard mass. The standard mass is either 1 g or 1 lb, and the associated length is, respectively, in meters or yards (For cotton ring spun yarns, an 840-yd hank is used; a 560-yd hank is associated with worsted and semi-worsted yarns, and a 256-yd hank with woolen as well as linen yarns).

  (Nm, Ne)

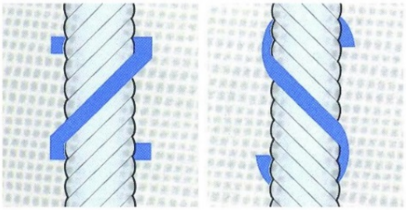
The most important properties of yarn

YARN TWIST

- yarn (as well as roving) is strenghtened by twist insertion
- it means the arrangement of fibres in direction of helix around the yarn axis expressed by the turns of fibre strand per unit length - 1 meter.
- Twist classification:

  a) according to the twist direction – right twist Z

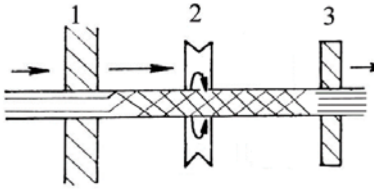
  \- left twist S



Right (Z) and left (S) twist direction in yarn [1]

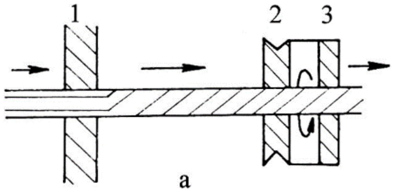
  b) according to the twisting method

  – false twist (in case of roving it is temporarily inserted by rounding or by false-twist tube)



1 … feeding device
2 … twisting device
3 … delivery device

\- true twist (inserted by roving frame, spinning frame)



1 … feeding device
2 … twisting device
3 … delivery device

[1] http://www.saviospa.it/ Accessed 2011-07-07

The most important properties of yarn

Tensile strenght

- an ability of material to resist tensile force action
- force needed to break of fibrous assembly
- very important yarn property
- depends on fineness ⇒ **tenacity** is evaluated (maximum specific stress)

$$\sigma\,[N/tex] = \frac{F\,[N]}{T\,[tex]}$$

σ .. tenacity [N/tex]
F .. absolute strength [N]
T .. fineness of fibrous assembly [tex]

Breaking elongation

- maximum possible extension of the linear textile product at maximum tensile strenght
- it is specified as a percentage of the starting (clamping) length

$$\varepsilon_p = \frac{L_p - L_0}{L_0}.100$$

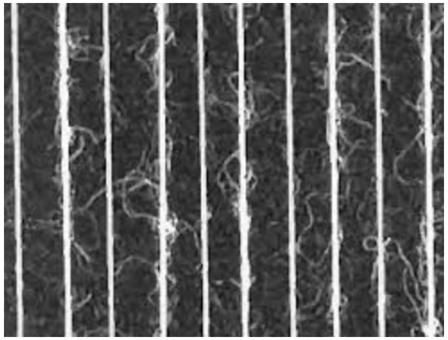
ε_p … breaking elongation [%]
L_p … length of yarn sample at maximum tensile strenght [mm]
L_0 … length of the sample between the jaws when clamping (clamping length)

- it depends on kind of fibre, yarn spinning technology, number of twist

The most important properties of yarn

Yarn hairiness

- amount of fibres or freely movable ends of the fibres or fibre loops protruding from yarn body
- various testing methods and expressions



Protruding hairs from yarn [1]

Hairiness can be expressed:

1) **Uster hairiness index H** – the total length of protruding fibres (in centimeters) per 1 cm of yarn

2) **Zweigle hairiness index S_i** – so called sum criteria – indicates the number of protruding fibres at distances 1 – 15 mm from the yarn edge
We usually used:
- sum criterion S12 – sum of number of hairs in the length categories 1 mm and 2 mm
- sum criterion S3 – sum of number of hairs in the length categories 3 mm and longer.

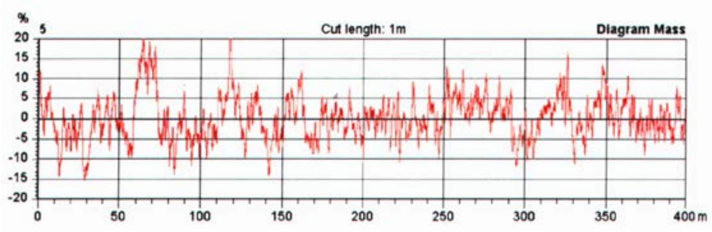
It depends on fibre length, fibre fineness, short fibre content, twist level, yarn count, machine delivery speed, technological parameters (technological stages included in yarn manufacturing, machine setting, ….).

[1] Sivakumar, S.: Effect of Fiber Properties on Yarn Hairiness in Ring Spun Yarn, http://textilelearner.blogspot.cz/2015/10/effect-of-fiber-properties-on-yarn.html. Accessed 2017-01-20

The most important properties of yarn

Mass irregularity (mass unevenness)

- It is a variation of fibre mass in the cross-section or in some section lengths of longitudinal fibrous product



It is caused by:

1) Random distribution of fibres in the cross-section of linear fibrous product
2) Random character of fibres
3) Faults during yarn production

- It is usually expressed by CV_{mass} [%] = variation coefficient of mass per unit length of yarn (in case of Uster Tester IV – 0.8 cm)

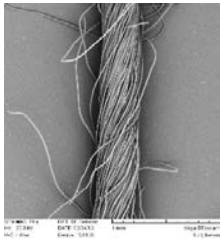
Mass unevenness influences variability of other yarn properties (e.g. tenacity, twist) and flat textile (for example appearance – it causes stripe, cloudiness, moiré effect).

<u>Spinning</u> = yarn production from staple fibers = staple spun yarn

<u>Staple-spun yarns (according to spinning technology and spinning methods):</u>

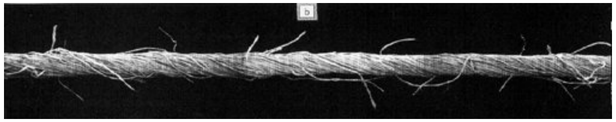
- carded, combed (cotton fibers, cotton type man-made fibers); woolen, worsted, semi-worsted (wooll, woolen type of man-made fibers)

Carded ring spun yarn



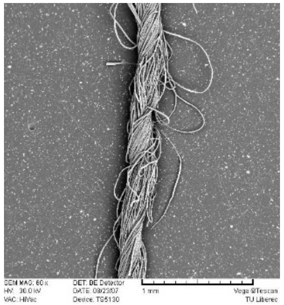
Combed ring spun yarn

- ring, compact, rotor, Air-jet spun yarns (Vortex, Rieter Air-jet), Dref yarn, Siro spun yarn

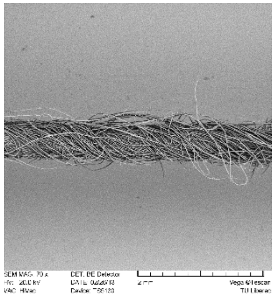


Compact spun yarn

Rotor spun yarn



Air-jet spun yarn

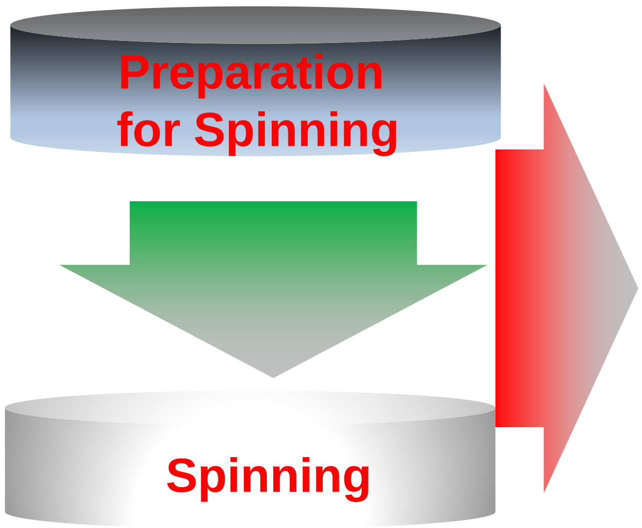


Dref yarn

Tasks of the Fiber to Yarn Conversion System

Fiber Mix

- Massive bulk of fibers
- Immense number of fibers
- High variability within fiber bales
- High variability between bales
- Trash and foreign matter
- Fiber neps, seed coats, short fibers



Yarn

- Very long linear strand (thousands of kilometers)
- Consistent appearance along yarn length
- Consistent properties along yarn length
- Trash free
- High productivity at economical level

Important fiber characteristics and properties for yarn production

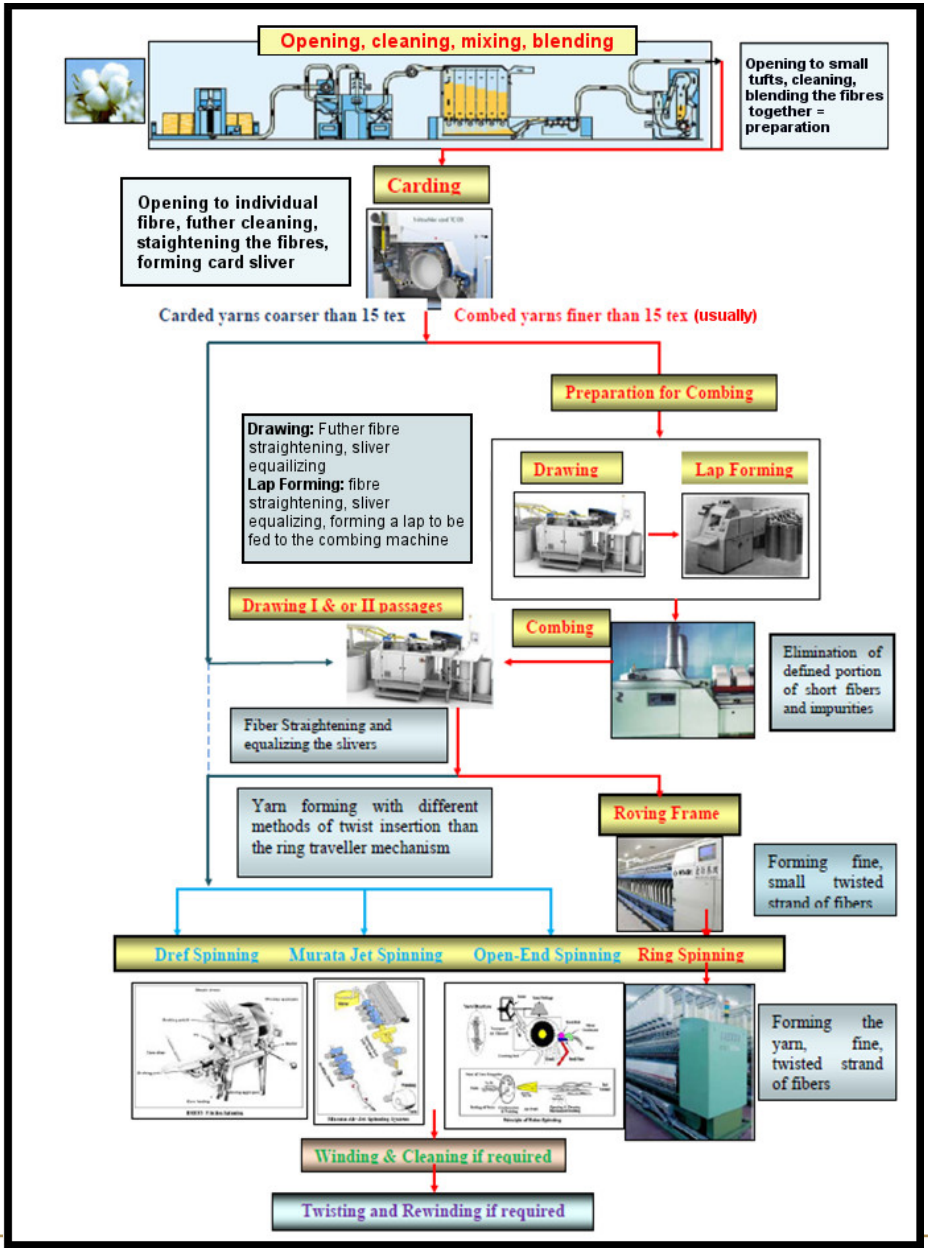
- fiber fineness
- fiber length and length distribution
- fiber crimp
- fibers stress-strain characteristics
- fiber rigidity
- fiber friction
- fiber cleanliness

The order of the most important fiber properties for yarn production

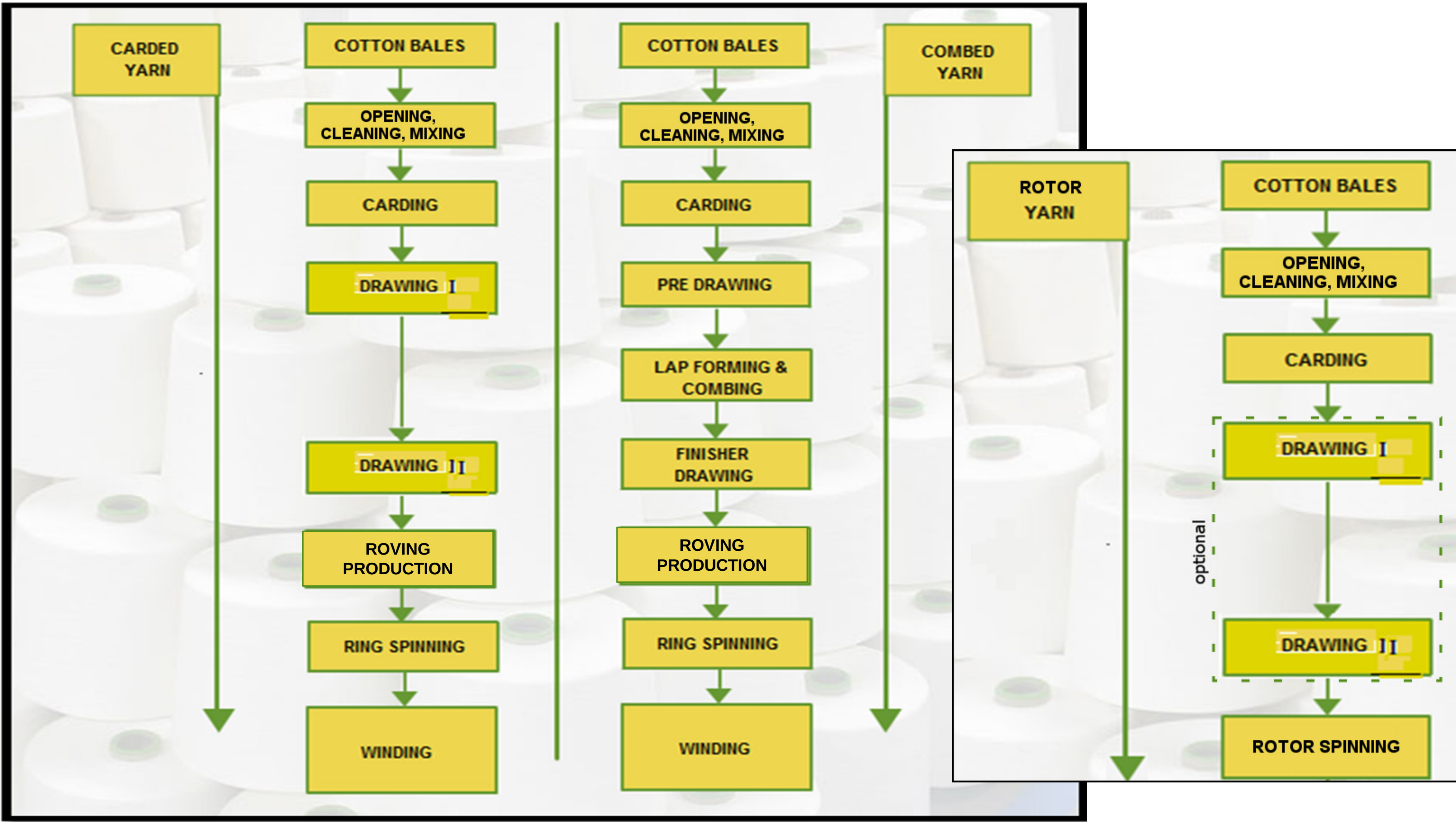
(according to The Rieter Textile Knowledge Base)

Order	Ring spun yarn	OE-Rotor spun yarn	Air jet yarn	Dref yarn
1.	Length	Fineness	Length	Friction
2.	Tenacity	Tenacity	Cleanliness	Tenacity
3.	Fineness	Length	Fineness	Fineness
4.		Cleanliness	Tenacity	Length
5.			Friction	Cleanliness

Principle of Cotton Yarn Production



Cotton Yarn Production Process Sequence



Blowing Room

Short Staple Pre-Spinning Machinery

Material Preparation

First stage of fiber processing consists of **opening, cleaning, blending** – the processes are inseparable.

Opening: progressively breaking up of the fiber mass into tufts;

Cleaning: removal of unwanted impurities by mechanical means. As the compress fiber mass is open-up, solid impurities are released to become the waste

- impurities can only be eliminated from surfaces of tufts. Within a progressive line of machines it is therefore necessary to create new surfaces continuously by opening the material

Blending: mixing of fibrous tufts from opened bales to produce a homogenous mass for consistent yarn properties (Fibers from different parts of the same bale, as well as between bales of the same lot of material differ in properties).

Main reasons for the blending

- **To produce a uniform product**
- **To reduce production costs**
- **To enhance specific property (in case of two or multi-component blends)**

Blowing Room

Short Staple Pre-Spinning Machinery

Material Preparation

It is realized by employing multifunctional equipments integrated into the compact line = BLOWING (BLOW) ROOM.

Tasks of the blowing room:

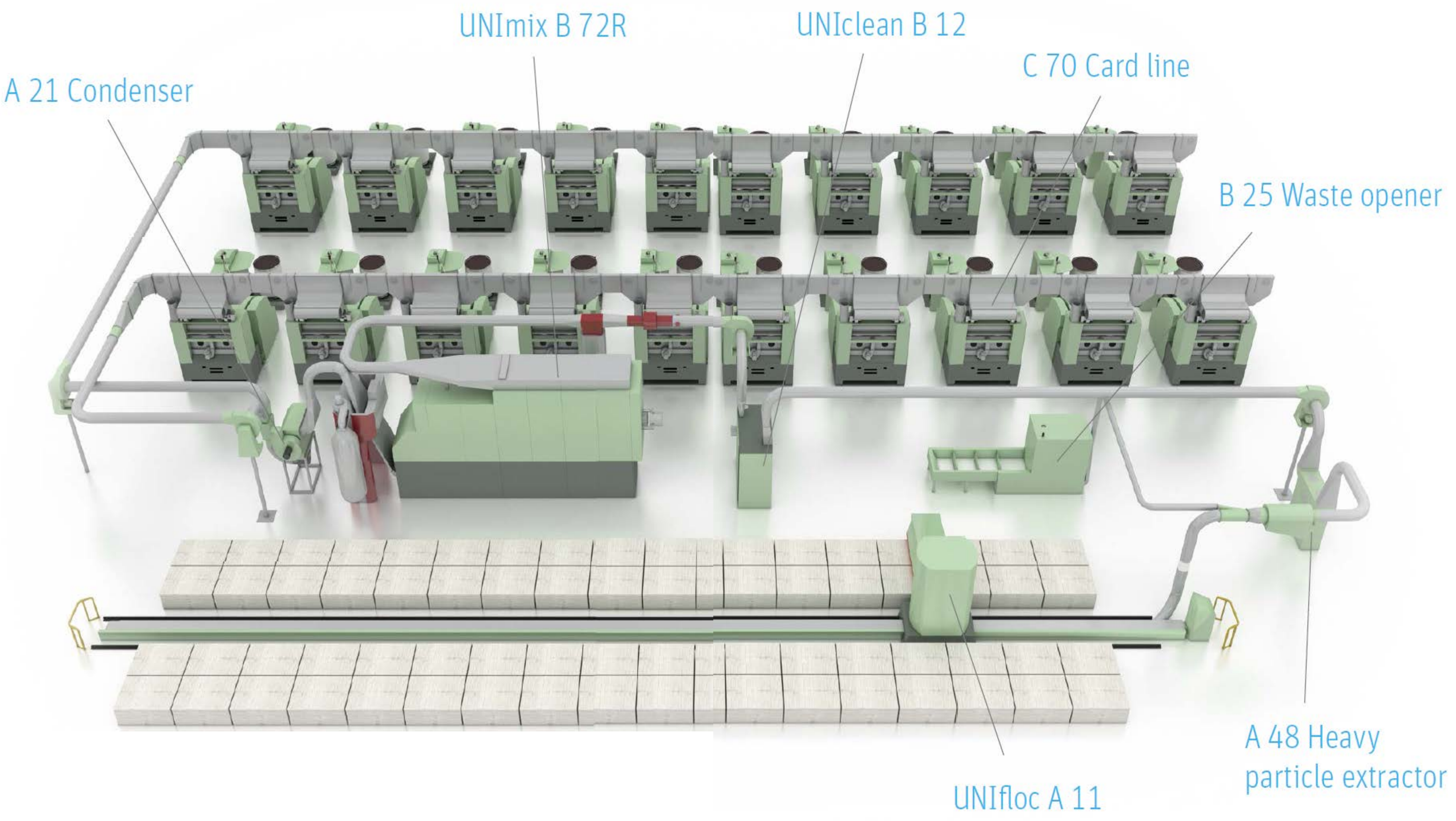
- **Open the material into very fine tufts**
- **Eliminate most of the impurities**
- **Eliminate dust**
- **Provide a good blend**
- **Evenly feed a material to the card**

Approximately 40 - 70% of the impurities are removed at the end of blow room. It is dependent on the raw material, and the machines.

And this has to be done:

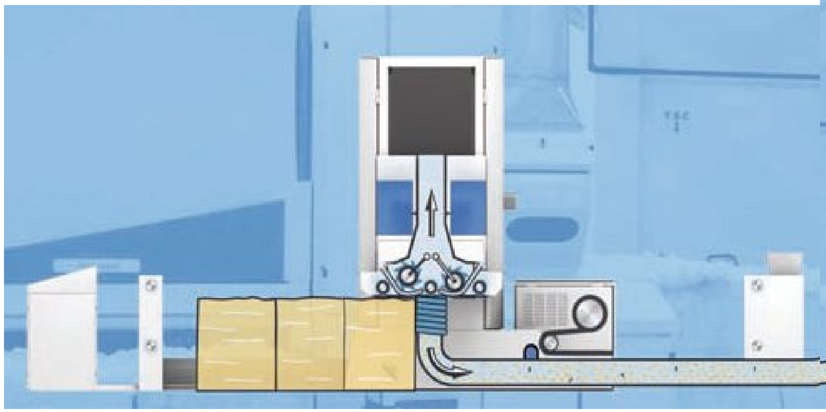
- with very careful treatment of the raw material;
- with maximum utilization of the raw material;
- while assuring the optimum level of quality.
- high operational efficiency;
- high economy;
- high flexibility;
- machines of ergonomic design, i.e. safe and easy to handle, maintenance friendly, reproducible and stable settings

Blowing Room - Rieter

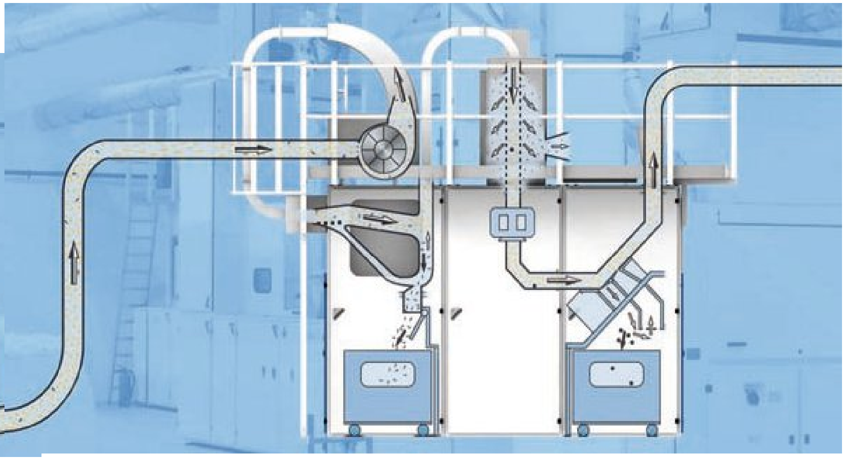


Rieter blowroom line – fine combed yarn

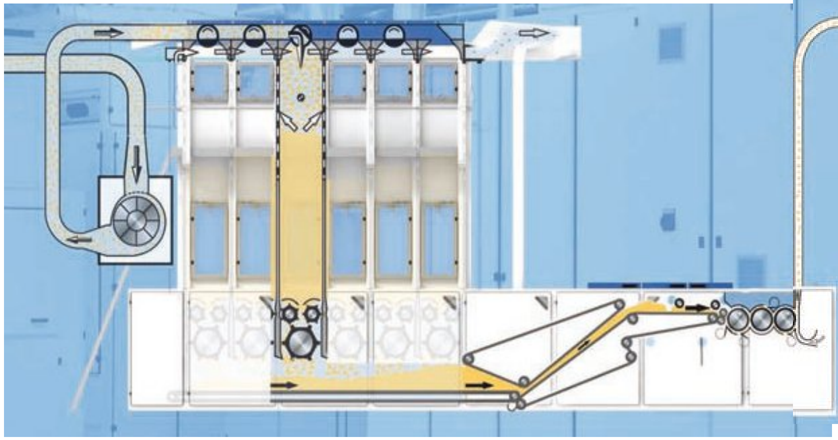
Blowing room - Trützschler



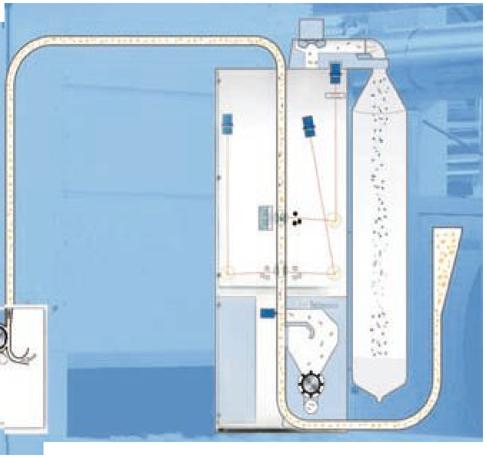
Automatic bale opener



Multifunction separator (removing metal parts, dust)



Mixing unit+ cleanomat

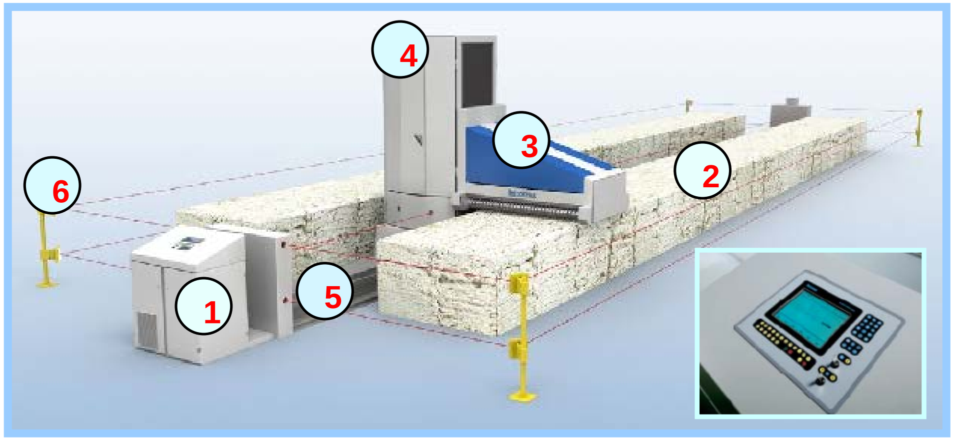


Securomat (foreign part separator)

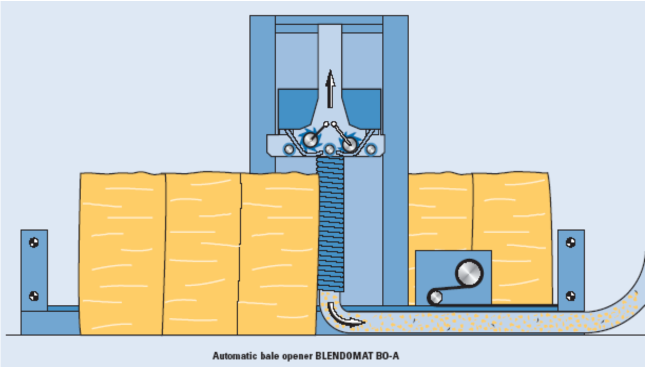
- New features are installed such foreign matter separator to prevent mixing of different fibers in the blend
- Completely automated and computerized control, vision system is enabled on-line

Automatic Bale Opener

It extracts material evenly from the bales, gently opens material, forms small flocks of equal mass.



(1) Control unit, (2) fiber bales, (3) working head with tooth discs, (4) swivel tower, (5) air duct for material transport, (6) protective light barrier



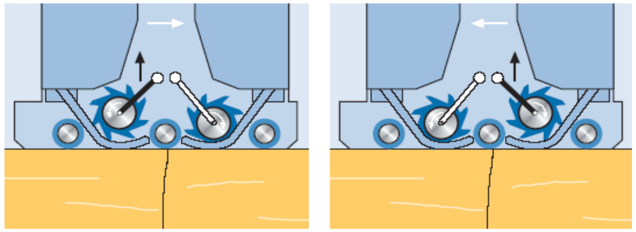
Blendomat BO-A, Trutzschler

Production is distributed to two opening rolls.
Three supporting rolls guarantee a solid stand of the bales.

Detail of opening roll – Unifloc - fa Rieter

Travel direction to the right:
The left roll is lifted

Travel direction to the left:
The right roll is lifted



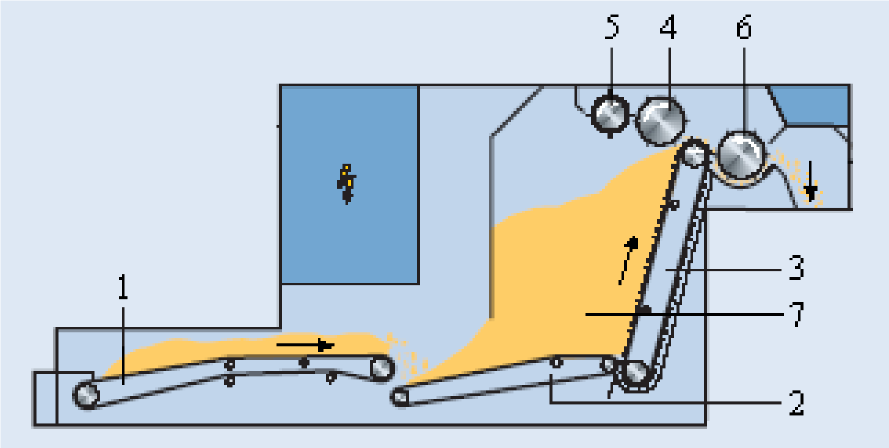
The penetration control mechanism of the opening roll guarantees always equal tuft sizes and an even distribution of production between the rolls

The BLENDOMAT BO-A with a working width of 2300 mm even accommodates up to 200 bales (1 - 3 bale groups). Working rate 2000 kg/hod.

Blending Bale Opener

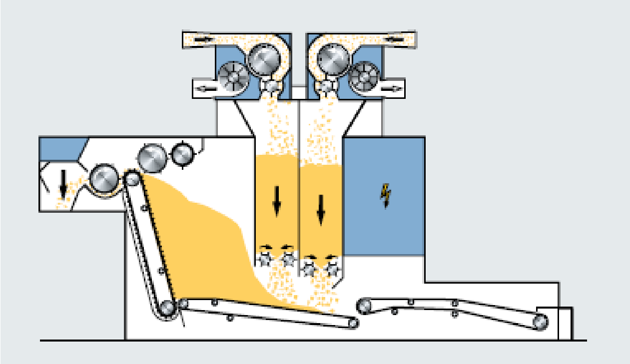
Can be used :

- As a supplement to the Automatic bale opener
- Instead of the Automatic bale opener (when processing small lots)

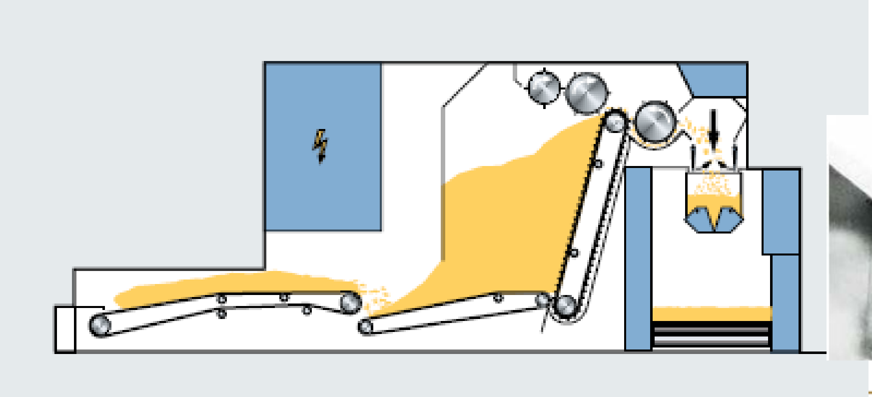


(1) Feed table, (2) Feed lattice, (3) Inclined spiked lattice, (4) Evener roller, (5) Cleaning roller, (6) Delivery roller (strip roller)

- **Opening fiber tufts into smaller one, fibers pre-blending**
- Several machine designs



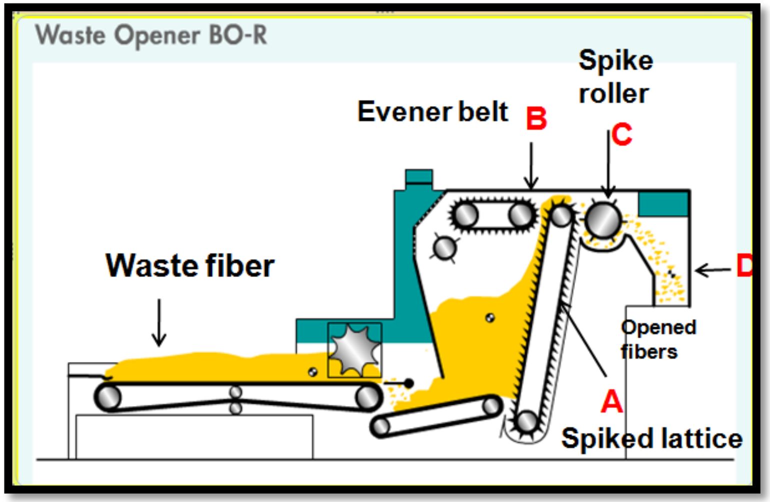
- It can be used for blending various raw materials (cotton + man-made fibers) – machine equipped with weighing pan



Waste Fiber Feeder

Mostly, raw cotton are used together with a small proportion of clean waste and possibly some recycled fibers blended with the raw material.

- Waste opener – part of the blow room – open the waste fibers



Type of waste used for cotton yarn production

- clean waste such as broken ends of sliver, lap and web;
- filter strippings from the draw frame, roving frame, ring as well as rotor spinning machines;
- comber waste for the rotor spinning mill;
- recycled fibers from dirty waste in the blow room and cards
- fibers torn out of hard waste such as roving, yarn and twisted threads.

Average amount of recycled fibers that can be added to the normal blend (according to Rieter):

Ring-spun yarns:

carded up to 5%

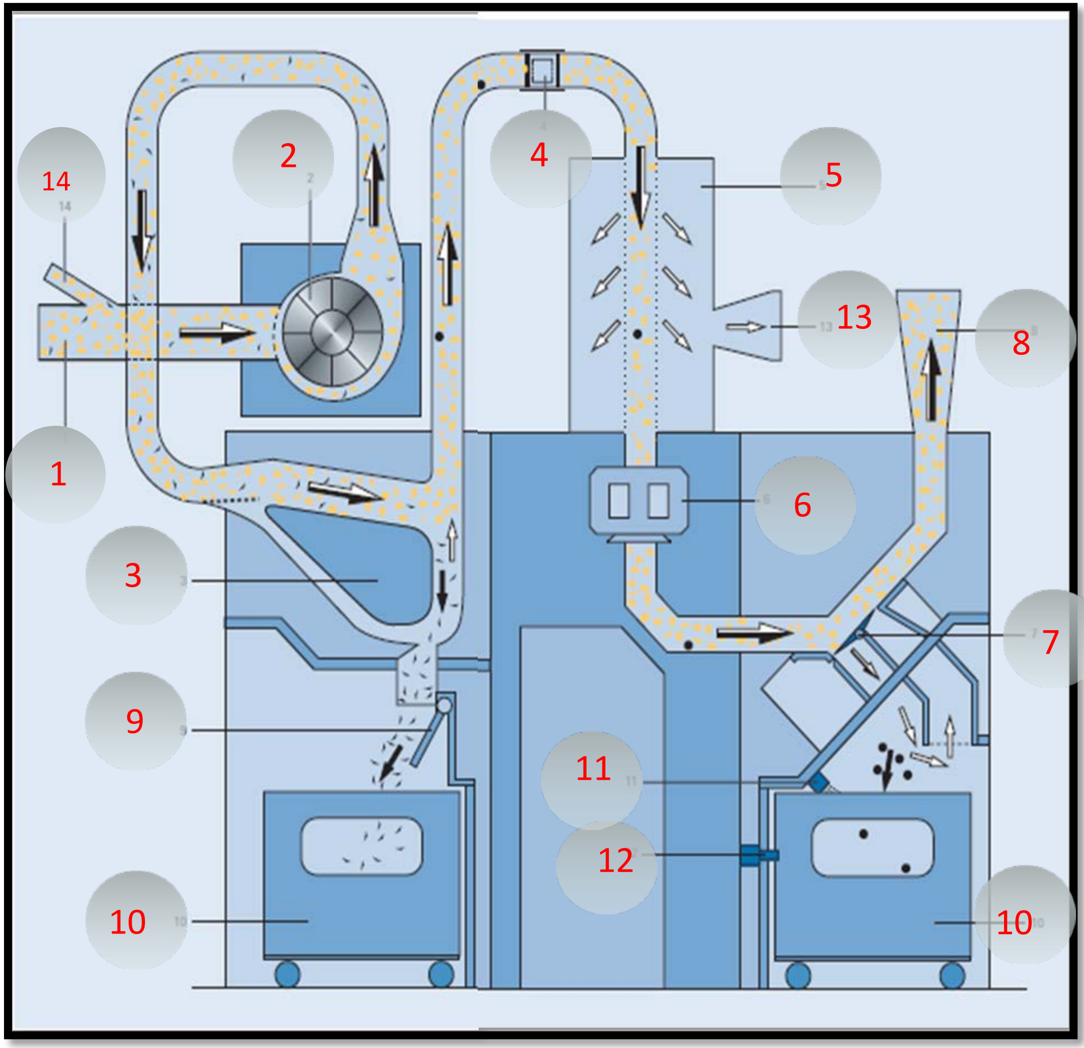
combed up to 2.5%

Since the waste is usually made up of fibers that have previously passed through the blowroom, it is important to keep further mechanical treatment to a minimum, so as to reduce fiber breakage.

Heavy Particle Separator

It detects and extracts heavy particles, dust, metal

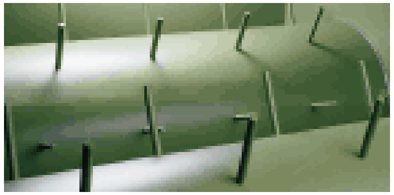
1 The material is sucked off an automatic bale opener
2 Fan automatically controls the constant negative pressure
3 A new guiding profile for the aerodynamic heavy particle separator
4 The spark sensor detects burning material
5 In the air flow separator the dusty air is separated
6 metal detector detects any kind of metals
7 The diverter is actively opened and closed
8 A fan, in front of the mixer, sucks the material off here.
9 A flap feeds the separated heavy particles
10 The two waste containers are large-size
11 A fire extinguishing unit extinguishes the burning material in the waste container
12 A heat sensor monitors the waste container for fire
13 The dusty exhaust air
14 Opened waste



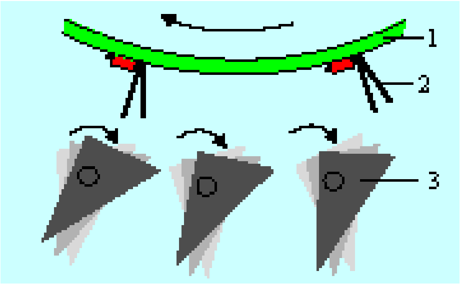
Multi-Function Separator SP-MF

Intensive Opening and Cleaning

Opening fibers tufts (the disentangling of the fiber mass) occurs progressively using spike, pin or saw-tooth wire covered rollers.

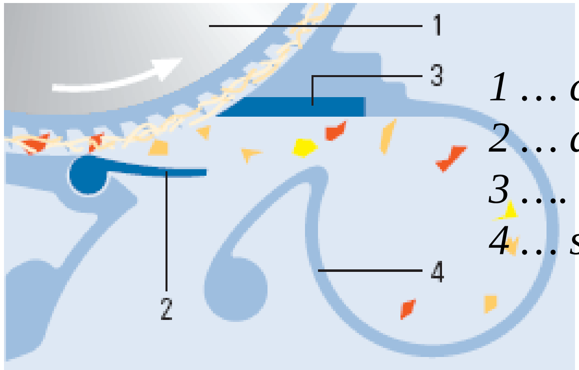


Light particles of impurities (such as dust) are freed and can be removed by air currents. Larger particles of leaf, seed, dirt and sand that are lodged between fibers are loosened and sucked into channel. Some imp. are removed by beating the tufts against grid bars or perforated plate.



1 .. opener roll
2 …spike of opener roll
3… adjustable grid

Fiber tuft with impurities is thrown against grid due to the spike. Impurities bounce off grid, fall under machine and are ejected to waste; fiber tuft is drawn back into opening process.



1 … cleaning roll
2 … deflection plate
3 …. mote knives
4 … suction hood

Knife-edge suction slot device

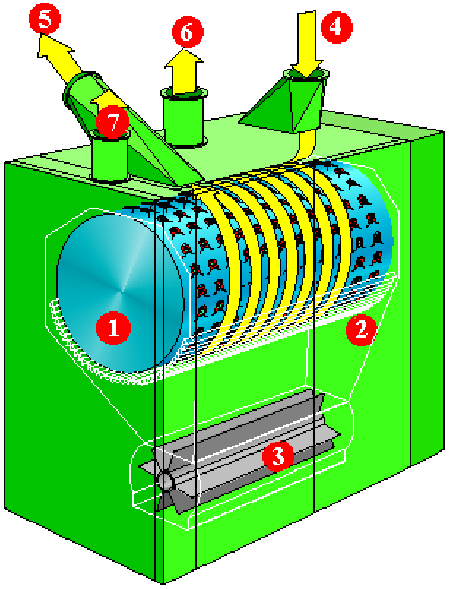
Removal trash particles by imbalance of centrifugal and aerodynamic forces on the particles.
Small impurities are sucked in channel

Intesive Opening and Cleaning

Machines for intensive opening and cleaning:

- various design
- 2 main groups:

A) opening in free flight (gentle, but less intensive treatment of the fiber)

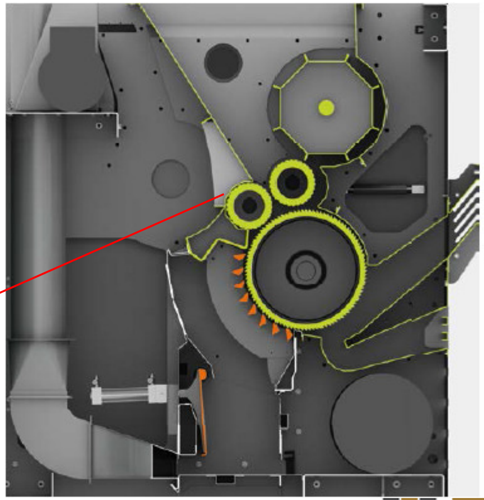


1. Cleaning cylinder
2. Cleaning grid
3. Airlock cylinder
4. Material feed
5. Material outlet
6. Exhaust air to filter
7. Waste removal

UNIclean B12 – Rieter

B) opening in the clamped condition (intensive, but less gentle) –

- it requires special feed device – usually set of rollers

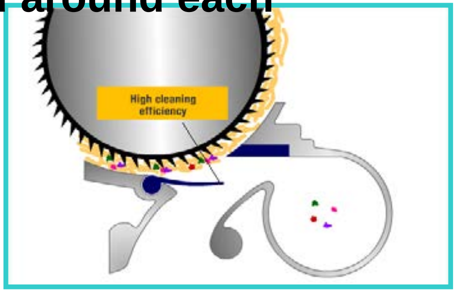


UNIstore A79 - Rieter

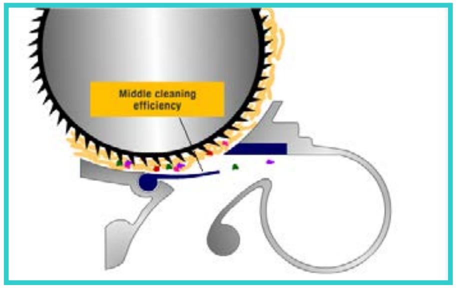
Intensive Opening and Cleaning

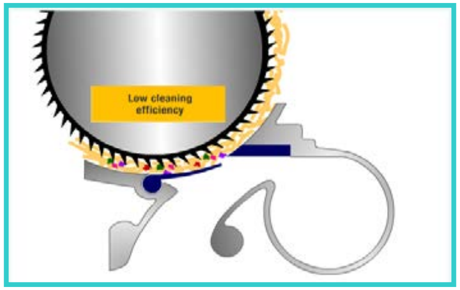
Optimum Setting of Cleaning

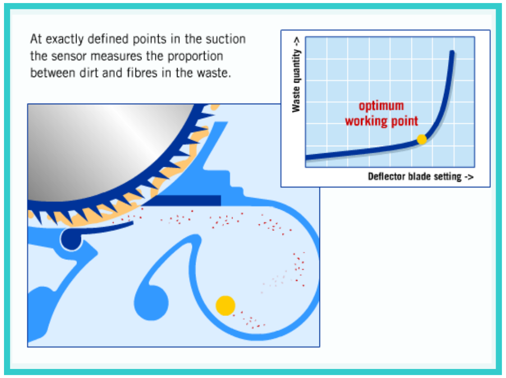
Thruetzschler company: Set of opening and cleaning machines is replaced with one machine with set of opening rollers = multi-roller cleaner – Cleanomat system
Tasks: intensive opening and cleaning of mini-tufts. Fine trash fragments are released and then they are extracted using knife-edge slot device positioned around each beater.

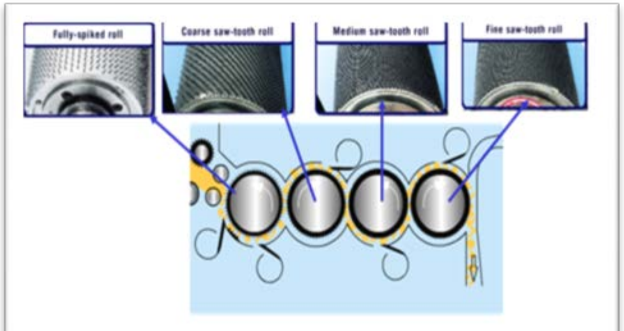


Gentle opening is achieved by having the first beater clothed in pins angled ca. 10° from the vertical, and the remaining beaters having saw-tooth clothing, the tooth angle increasing from roller to roller. The teeth density (number of points per cm^2) should also progressively increase from beater 1 to 4, depending on fineness of the fiber being produced. Importantly, the beater speeds should progressively increase from beater 1 to 4 (for example 300, 500, 800, 1200, $rmin^{-1}$). Hence, the mean tuft size is decreased (approximate figures) from 1 mg by the first beater to 0.7 mg, 0.5 mg and 0.1 mg by the second, third and fourth beaters, respectively. It is only the fourth beater that reaches a sufficiently high surface speed at which the finest trash particles are ejected.









Cleaner CLEANOMAT CL-C 4 with 5 cleaning points

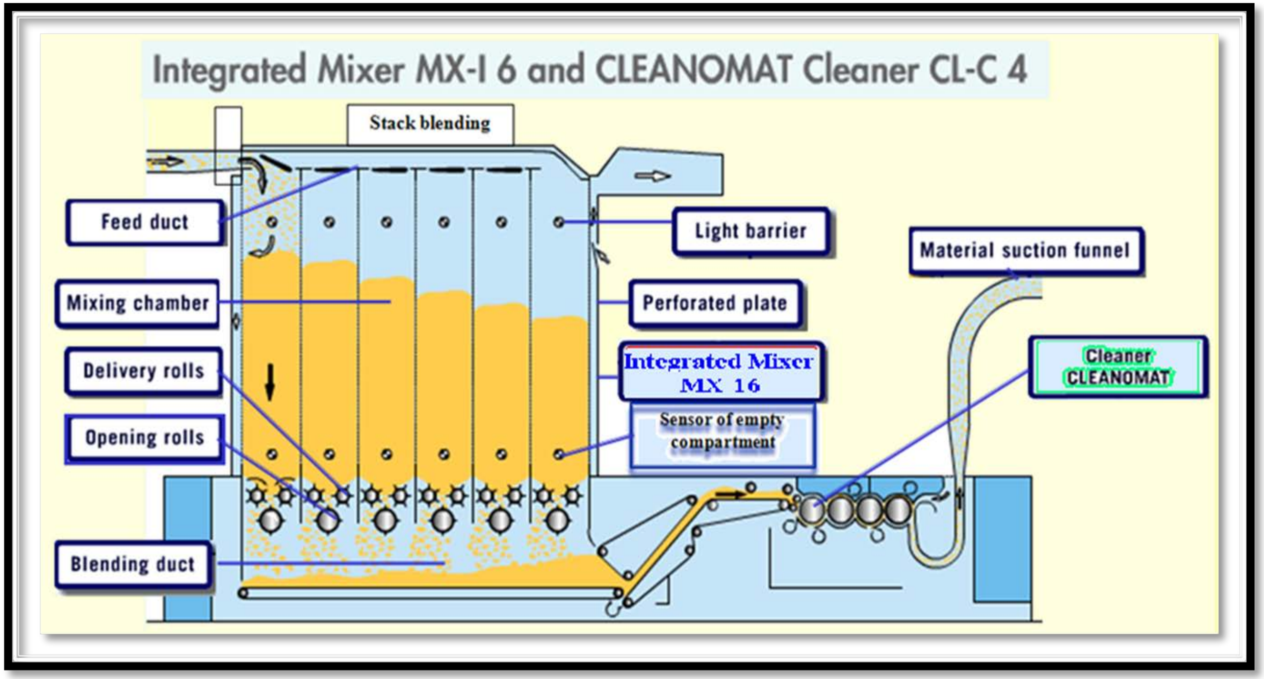
Sensor measures the proportionality between trash and fiber in the waste, and sets the deflection plate at optimum value

Cleanomat CL-C4

Blending/Mixing

- Task: intensive mixing of fibre tufts

Intensive blending in a suitable blending machine must be carried out after separate tuft extraction from individual bales of the layout. This blending operation must collect the bunches of fibers arriving sequentially from individual bales and mix them thoroughly

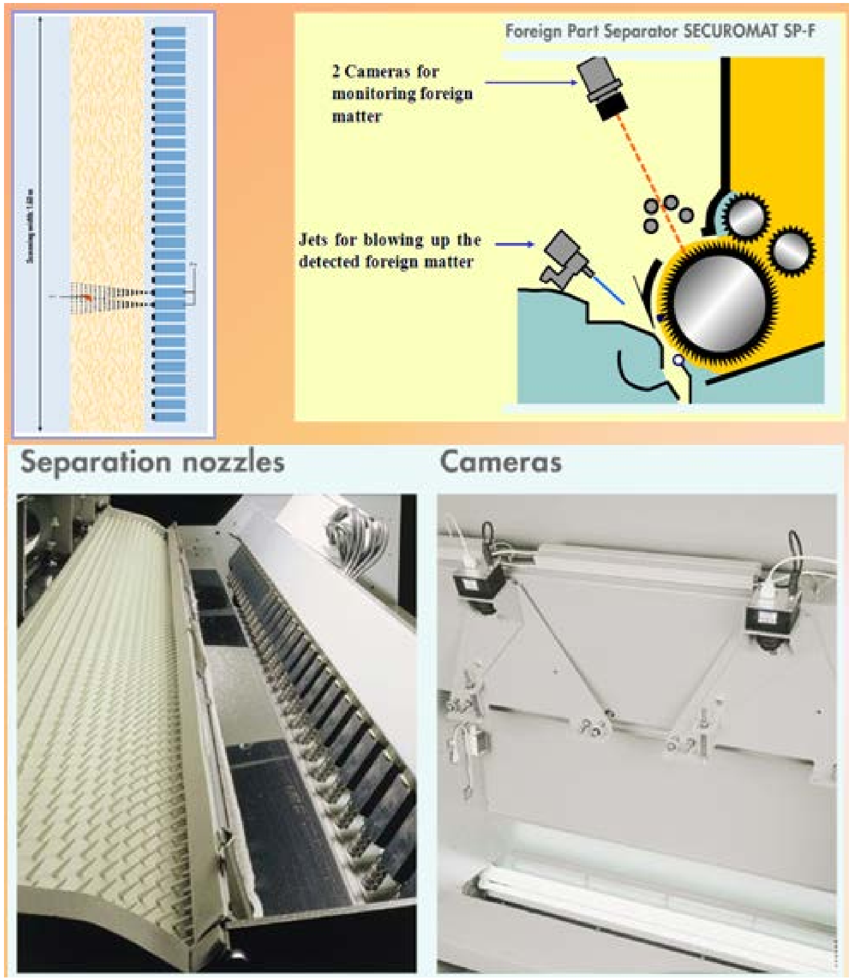


Foreign Particle Separator

It detects and separates foreign parts from the fiber flow that is different in color (foreign matter as remains of wrapping, fibers covered with oil or grease, the remains of colored material coming from marker ribbons from the picked cotton packages, foreign fabric, plastic, feathers, etc.)

Fiber flow is optically scanned by quick color camera in this separator, when foreign fiber (or particle) is detected, it is blown into a waste suction device by means of compressed air impulse coming from a nozzle.

Additional lighting materials with polarized light or using UV-modul - transparent materials or fluorescent materials can be visible and recorded by camera and then extracted using air impulse from nozzle



Details of Cameras and Separation Nozzles

Cotton should be highly opened.
This is provided directly before feeding the material to the card.

Carding Process

Introduction:
The card is the heart of the spinning mill or Well carded is half spun.

Definition: Carding is the action of reducing tufts of entangled fibers into a filmy web of individual fibers by working the tufts between closely spaced surfaces clothed with opposing sharp points.

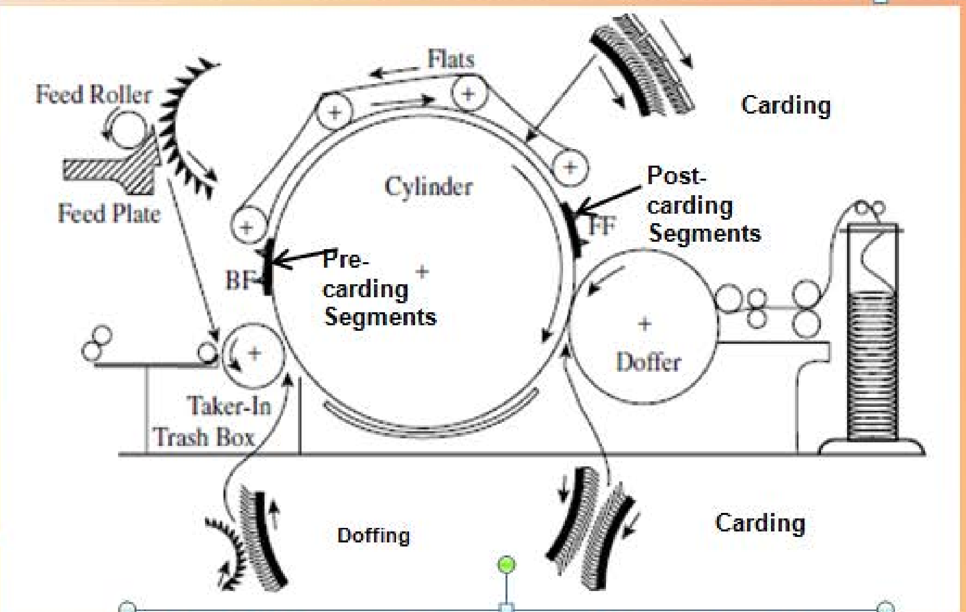
THE TASKS OF THE CARD
Opening tuft into individual fibers, Elimination of impurities, Elimination of dust, Disentangling of neps, Elimination of short fibers, Fiber blending, Fiber orientation, Sliver formation.

Principle of carding - Two saw-teeth (or small wire hooks) clothing are oppositely disposed. Both clothing move at different speed. One of them is fast (very fast). Second one is very slow. Points of super-fast clothing pull individual fibers from flocks. Opening of flocks into fibers is realized. Fibers are straightened simultaneously. Short fibers press into slow clothing

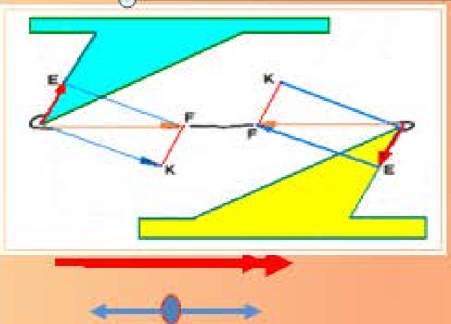
Two main types of card can be used for the processing of cotton, wool and man-made fibers: 1. revolving flat card , 2. roller card (worsted card, woolen card)

High production machine. Production rate increased since 1965 from 5 kg/h to 220 kg/h.
Rate of production and quality should be optimized (close relationship between increases in production and reductions in quality).
Concept of carding machine is unchanged since 1770.

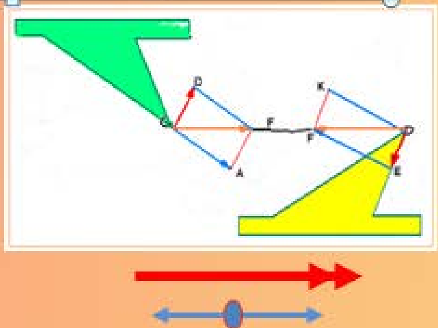
Revolving Flat Card



Basic Elements of carding Machine

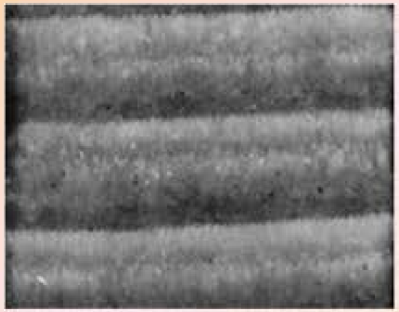


Carding action



Doffing action

Revolving flats



Cotton flats strip

Drawing

Drawing **is the term applied to the operation involving the doubling and roller drafting of slivers.**

Doubling **is the combination of several slivers that are then attenuated by a draft usually equal in number to the slivers combined, thereby resulting in one sliver of a similar count.**

Roller drafting **is the process of attenuating the count of a material using a combination of pairs of rollers.**

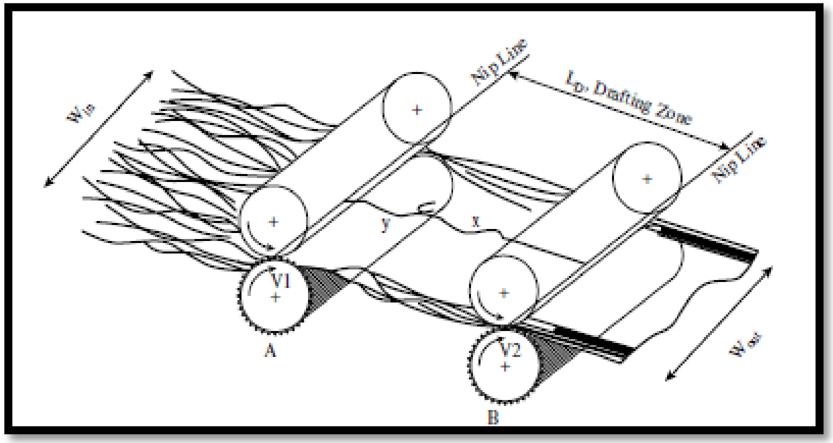
Draft

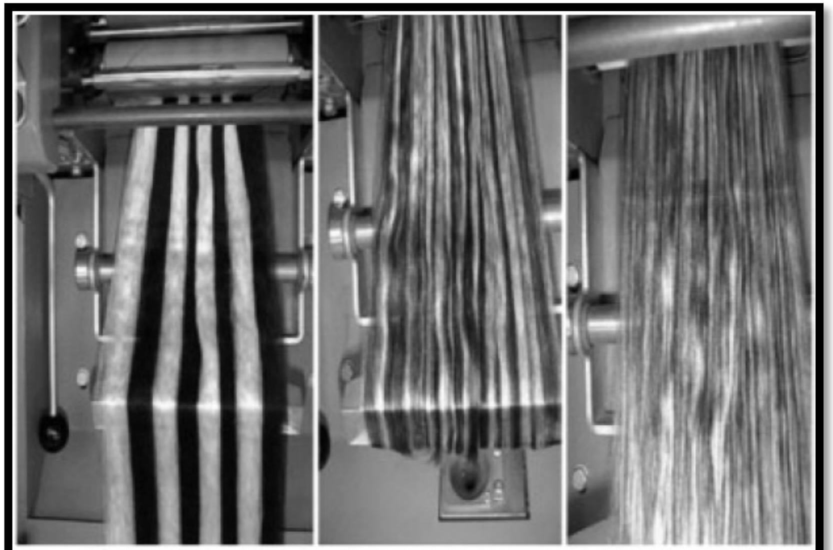
- **Means sliver refinement (attenuation)**
- **Equal to the factor by which the sliver count is reduced.**

$$Draft = \frac{initial\ count\ [tex]}{final\ count\ [tex]} * Doubling$$

- **Equal to the ratio of roller peripheral speed**

$$Draft = \frac{speed\ of\ delivery\ (front)\ rollers\ [m/min]}{speed\ of\ feeding\ (back\ )\ rollers\ [m/min]}$$



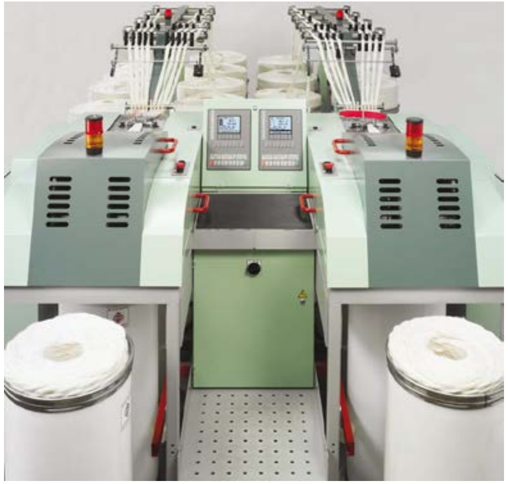


First Passage Drawing | Second Passage Drawing | Third Passage Drawing

Objective of Drawing

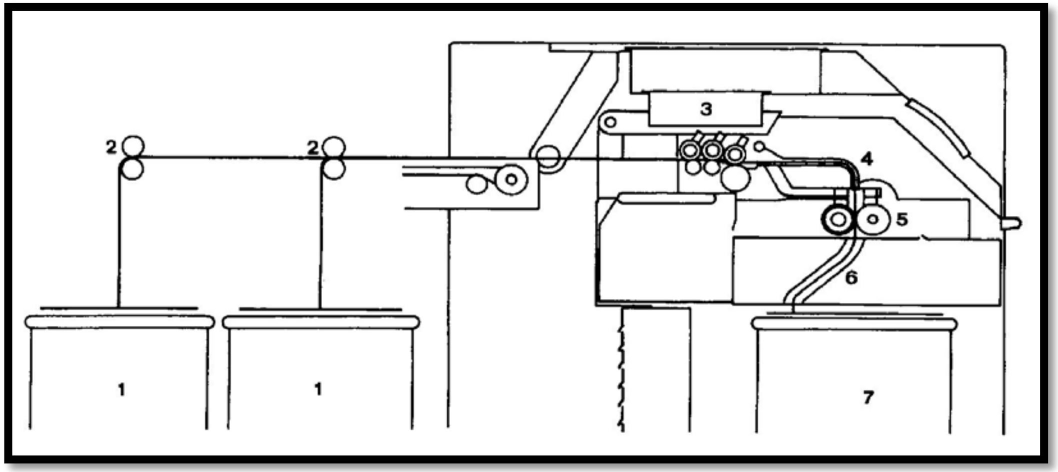
<u>The tasks of the draw frame:</u>
Sliver Equalizing, Fiber Blending, Fiber Straightening and Parallelizing, Sliver attenuation and Dust removal

Equalizing is preformed by doubling and optionally by additional autoleveling. Drafting increases material mass irregularity .



Draw frame RSB-D22 - Rieter

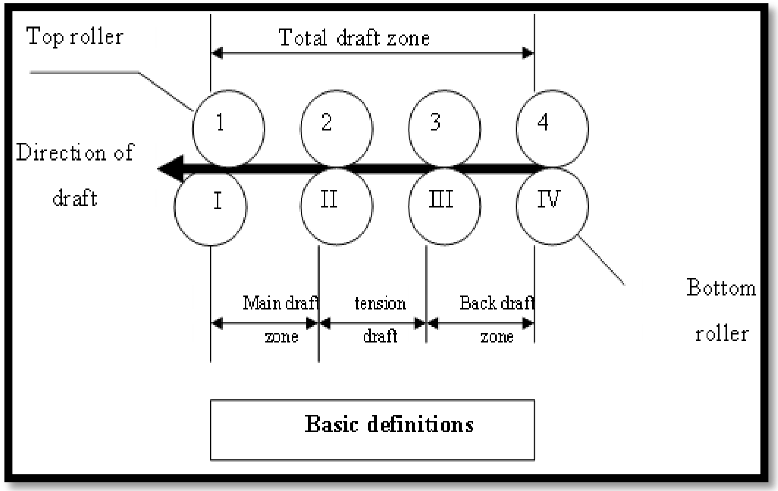
<u>Main Parts of the draw frame</u>



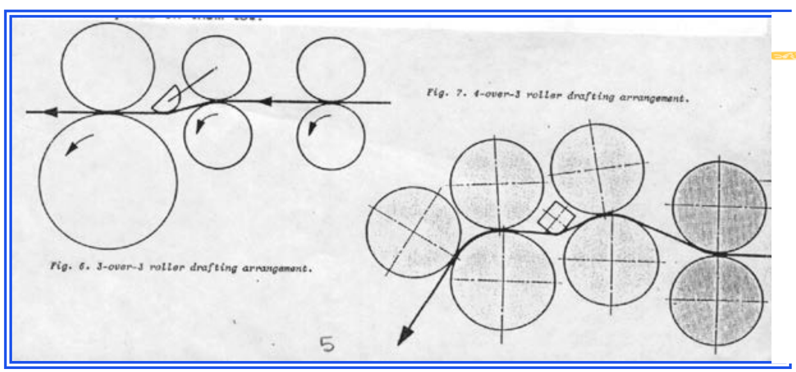
1) Can , 2) Feed roller, 3) Drafting system, 4) Guide tube, 5) Calenders, 6) Coiler and 7) Can with drawn sliver

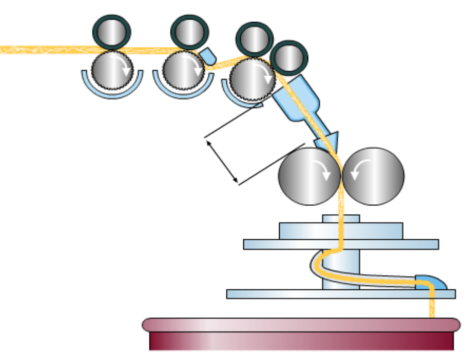
Features of Drawing Frame

The drafting arrangement



Today 3 over 3 or 4 over 3 roller drafting system with pressure bar is used





Combing Process

The combing process is normally used to produce smoother, finer, stronger and more uniform yarns. Combing is also used for upgrading the quality of medium staple fibers

• Production coast is increased.

<u>Tasks of combing:</u>

• **Elimination of precisely pre-determined quantity of short fibers (8- 25%)**
• **Elimination of the remaining impurities**
• **Elimination of a large proportion of the neps**
• **Improve straightening and alignment of fibers**
• **Formation of a sliver having maximum possible evenness**

Elimination of short fibers improves mainly the <u>staple length.</u>

Combing Process

Compared to carded yarn, combed yarn:

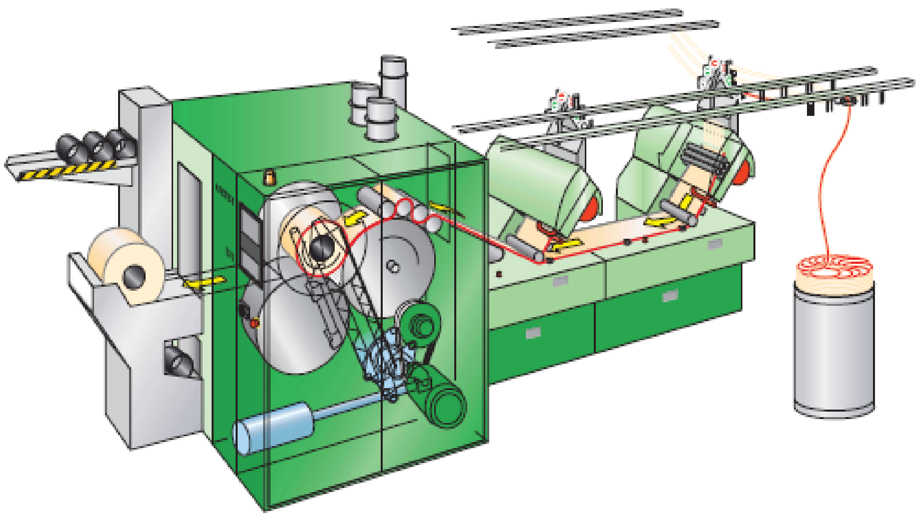
- is stronger (higher value of tenacity),
- has higher breaking elongation,
- has low hairiness,
- yarn is more smooth, without impurities, but less warmer
- yarn has lower mass irregularity (lower CVm value)
- Yarn count usually: (5 – 25) tex

Combing operation requires good sliver quality – sufficient fiber alignment and parallelization, sliver evenness and, in the case of cotton combing, a suitable form of feedstock (sliver lap) = preparation for combing is necessary

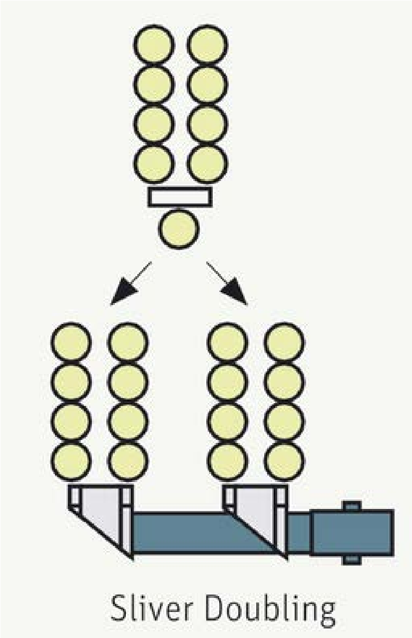
Preparation of Stock for Combing

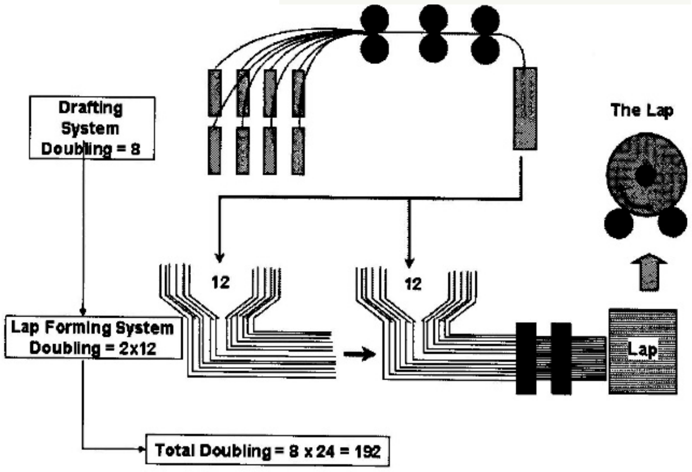
Modern lap preparation

- the sliver doubling process, in which a drawframe provides the first passage and a sliver doubling machine follows as the second passage



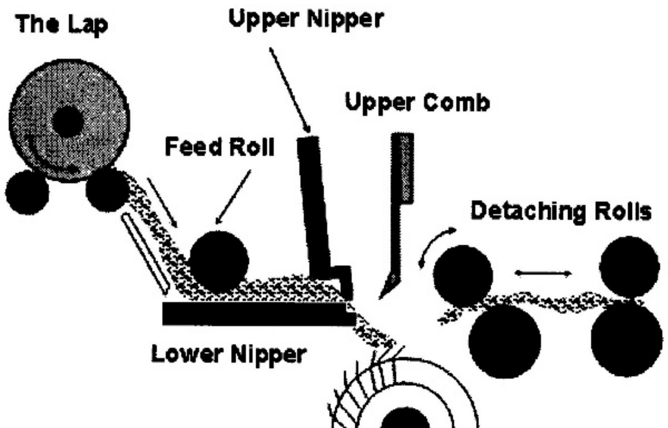
Unilap from Rieter (drawing/lap)

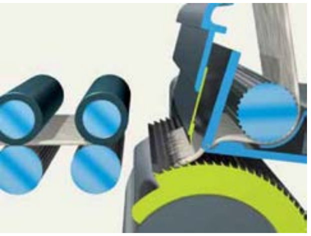


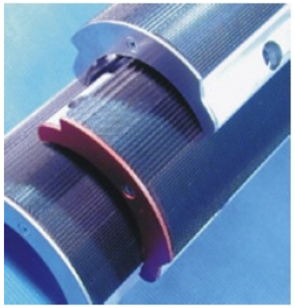


Combing Machine

Main parts of the cotton combing machine:







Circular comb is equipped segment with metallic clothing

Principle of combing:

- **The gradual penetration of the needles of combing drum through fiber fringes, held between nippers**
- **Impurities and fibers that are not held within a nip line are combed out (noils)**
- **Combed sheet is released from the nipper, delivered and placed upon the returned fibrous sheet combed previously (piecing), sliver is formed**
- **New fiber fringe is fed, impurities and extracted fibers are removed from combing segment**

Roving Frame (Speed Frame, Flyer Frame)

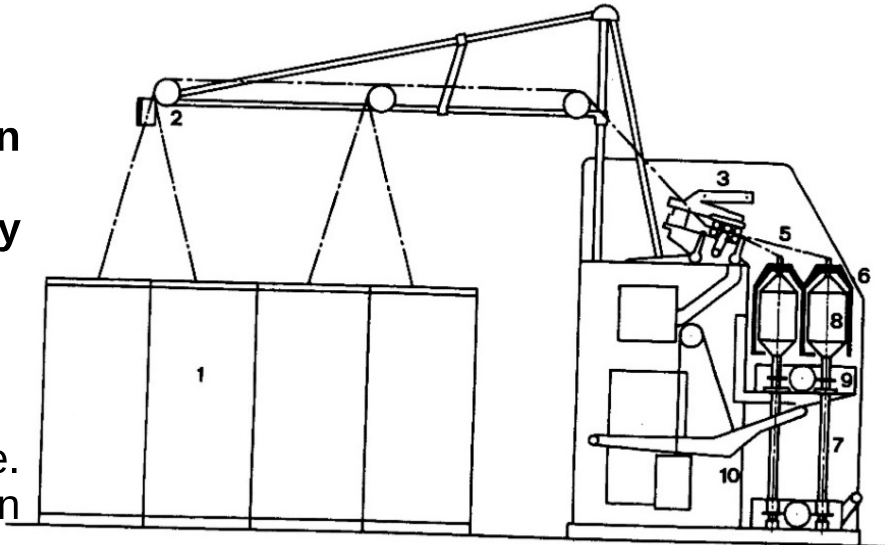
Tasks of the roving frame:

- Attenuation the sliver to a fine strand
- Strengthening drawn strand by inserting the twist
- Winding the roving on a package that can be transported (roving bobbin)

Imparting twist:

The flyer inserts twist. Each flyer rotation creates one turn in the roving

The strand has low level of twist - only „protective twist”



draw slivers cans (1) *transport rollers (2)*
drafting arrangement (3) *twisted roving(5)*
flyer (6) *spindle (7)* *bobbin (8)*
the bobbin rail (9) *lever (10)*

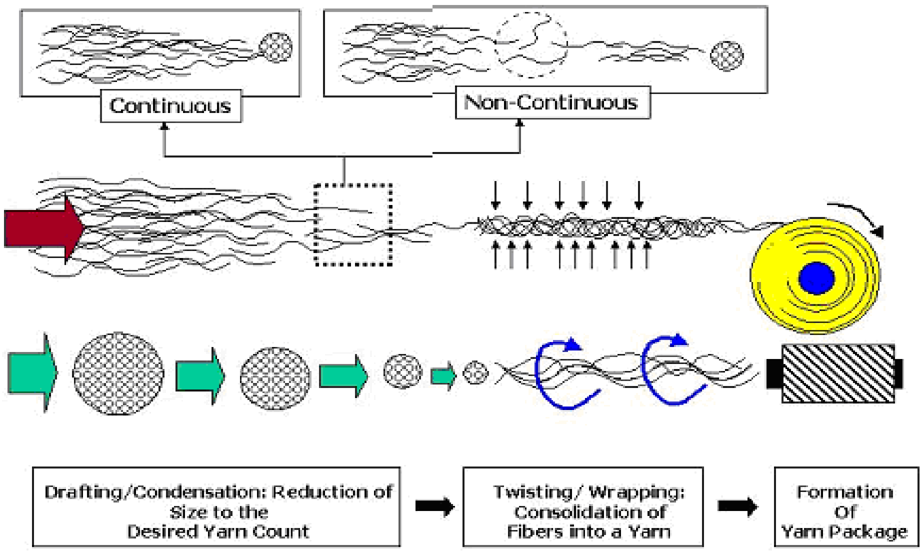
The flyer

one of the two legs has usually been “hollow”, i.e. with a deep guide groove that is open in a direction opposite to the direction of rotation

Spinning and the Ring Spinning Frame

General, Basic Principle of Spinning:

- **attenuation of the feed material to the required count**
- **insertion of twist into the attenuated fiber strand to bind the fibers together**
- **winding the spun yarn onto a bobbin to produce a suitable package**



The Basic Principle of Spinning

Ring spinning

The ring spinning is characterized by two main features:

1) Continuity of fiber flow from roving to yarn.

2) Tension-controlled spinning process.

The American Thorp invented the ring-spinning machine in year 1828. In 1830, another American, Jencks contributed the traveler rotating on the ring.

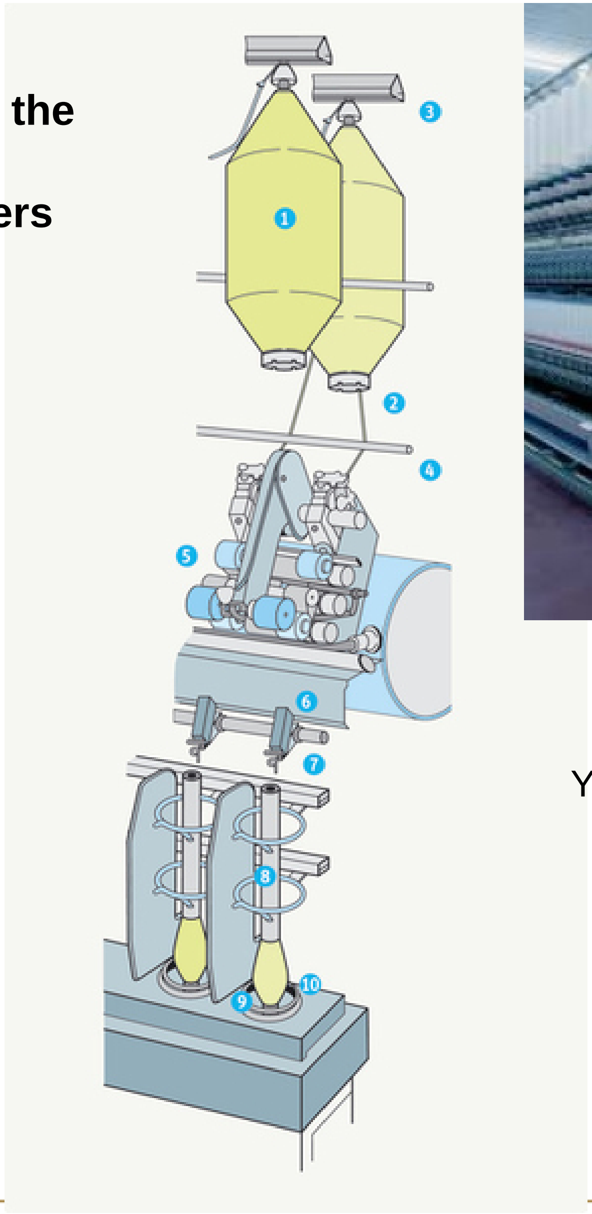
During the last 185 years, the machine has passed many considerable modifications, but the principle of yarn forming remained unchanged. In spite of the many introduced principles of yarn forming, the ring spinning frame will continue for some time for the following reasons:

- It is universally applicable, i. e. processes any material for any count, quantities.
- It delivers a yarn with optimal characteristics (regarding structure and properties).
- It is uncomplicated and easy to master.
- The know-how for operation is well established and friendly use.
- It is flexible as regards (blend and lot size.)

Ring Spinning Frame

Tasks of the ring spinning frame

- **draw the roving to its final count in the drafting system**
- **impart tenacity to the bundle of fibers by twisting it,**
- **wind up the resulting yarn in a cop**

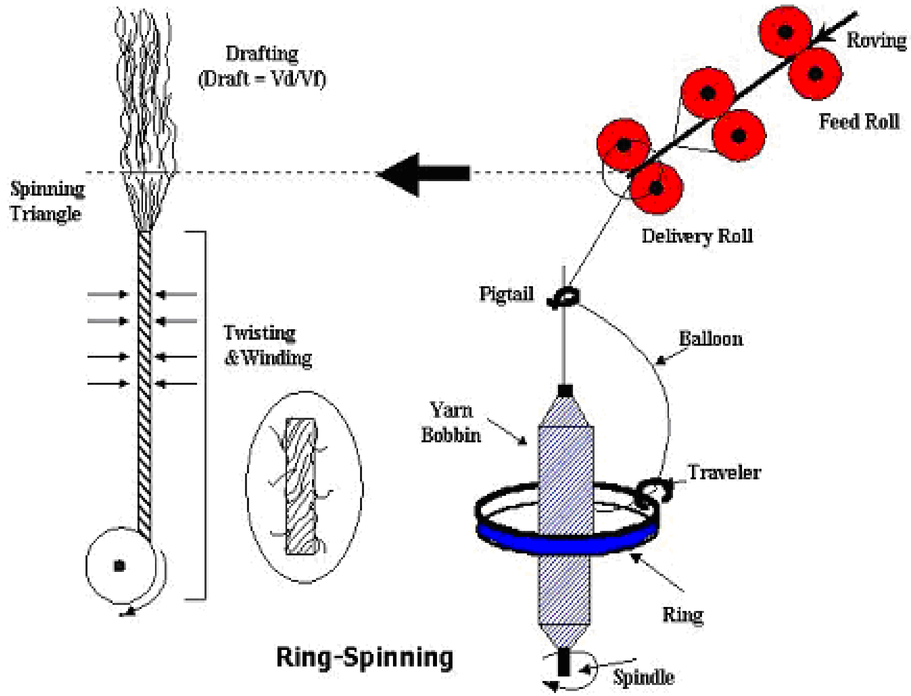


Parts of the ring frame

1 … roving bobbin
2 ... roving
3 … holder on the creel
4 ... guide bar
5 ... drafting system
6 … thin ribbon of fibers
7 ….guide eyelet
8 … spindle
9 ….traveller
10 ..ring

Yarn count ranges: (4 – 167) tex

Principle of Twist Insertion Mechanism

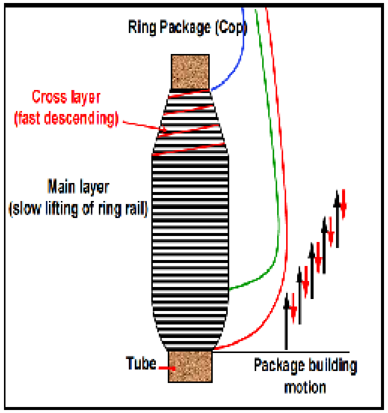


- Twist is provided by spindle, rotating at high speed thanks to circling of the traveller on the ring around the spindle.
- Each rotation of the traveller produces a twist in the yarn.
- The ring traveller has no drive of its own, it is dragged with spindle via the yarn attached to it.

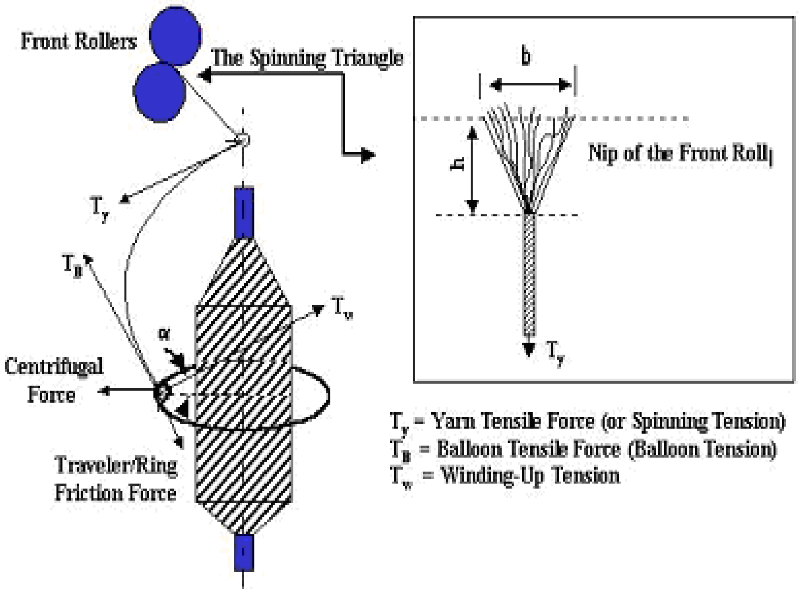
$$Twist = Turns/meter\,(t.p.m) = \frac{n_{spindle}\,(rpm)}{V_{delivery}\,(m/\min)}$$

The difference in speed between spindle and traveller causes the yarn winding on the cop by raising and lowering of the ring rail. The layer traverse of the ring rail is less than the full winding height of the tube. The ring rail therefore has to be raised slightly after each layer has been wound.

The increase or a decrease in twist is mainly a result of a change in the speed of the delivery roller. Thus twist level affects productivity.



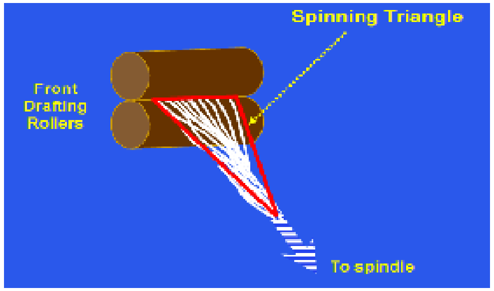
Spinning Triangle



Forces Applied on the Yarn During Ring-Spinning

The forces generated by motion of traveller and the pulling of the yarn through the traveller results in yarn tension that govern shape of spinning balloon

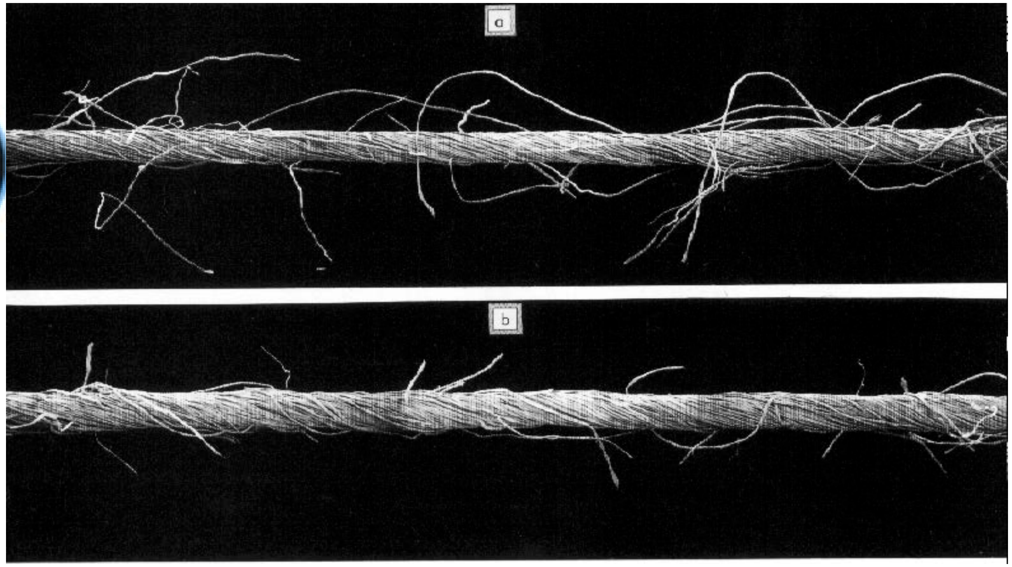
The tension and twist torque cause the fibers come together to form a triangular shape between the nip line of the front drafting rollers and the twist insertion point = <u>spinning triangle</u>



Compact Spinning

Compact spinning – modification of ring spinning
- was introduced in 1995.

Compact spinning is essentially a ring spinning with additional feature to reduce yarn hairiness in the so called condensing zone. This is done to improve surface integrity and increase yarn strength. Hairiness and tenacity are crucial for performance in downstream manufacturing operations.



Ring yarn

Compact yarn

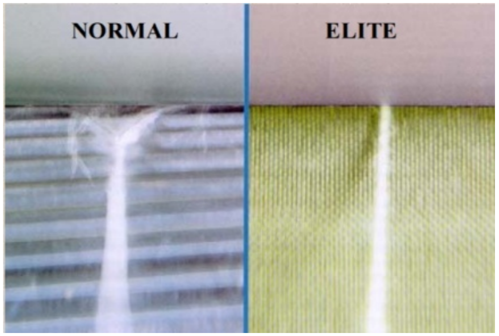
Compact yarn

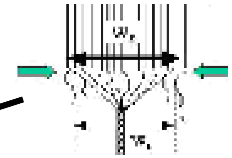
Principle of Compact Spinning

Due to condensing the fibers in a narrow path the spinning triangle is reduced.

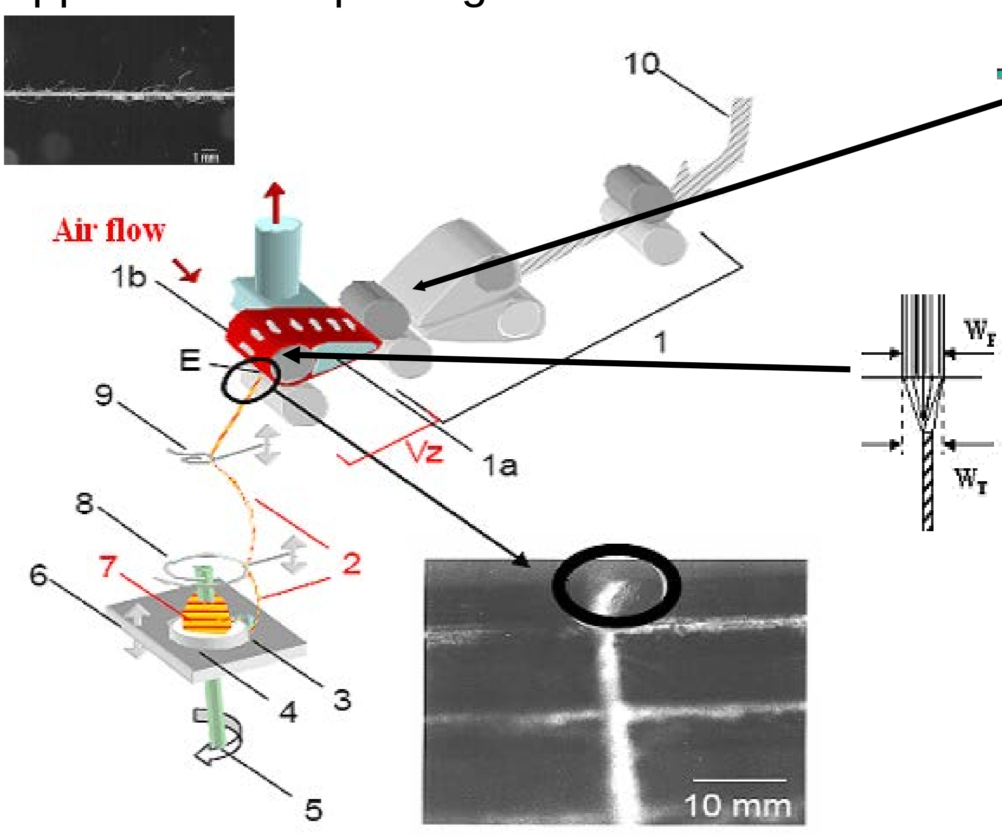
The condensing zone is placed before twisting paralelly following drafting arrangement.

There are two basic systems of condensing: air flow or mechanical system - air suction or magnetic system is applied for compacting the fibers

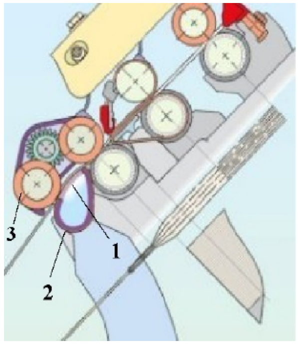




Conventional RS



1) Drafting arrangement
1a) Condensing element
1b) Perforated apron
V_Z) Condensing zone
2) Yarn Balloon with new structure
3) Traveler,
4) Ring
5) Spindle,
6) Ring carriage
7) Cop,
8) Balloon limiter
9) Yarn guide,
10) Roving
E) Spinning triangle of compact spinning

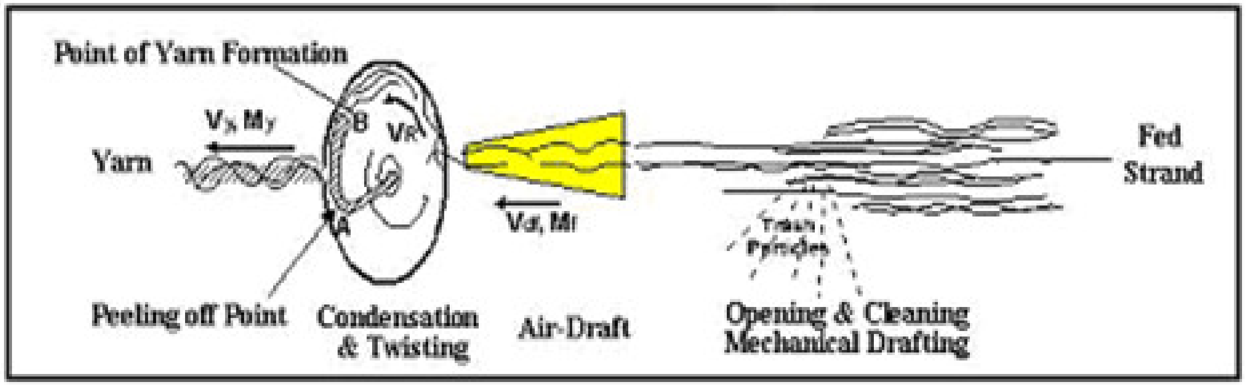


Open End Spinning – Rotor Spinning

Definition: Open-end spinning is a process in which fibrous material is highly drafted to the individual fibers, creating a break in a continuum of the fiber mass. The individual fibers are subsequently collected onto the rotor and then onto the open end of a yarn that is rotated to twist the fibers into the yarn structure to form a continuous yarn length. The length of yarn spun is then wound to form a package.

Thus the twisting action occurs simultaneously but separately from winding.

Yarn count range:
10 – 200 tex
(fa Saurer- up to 588 tex)



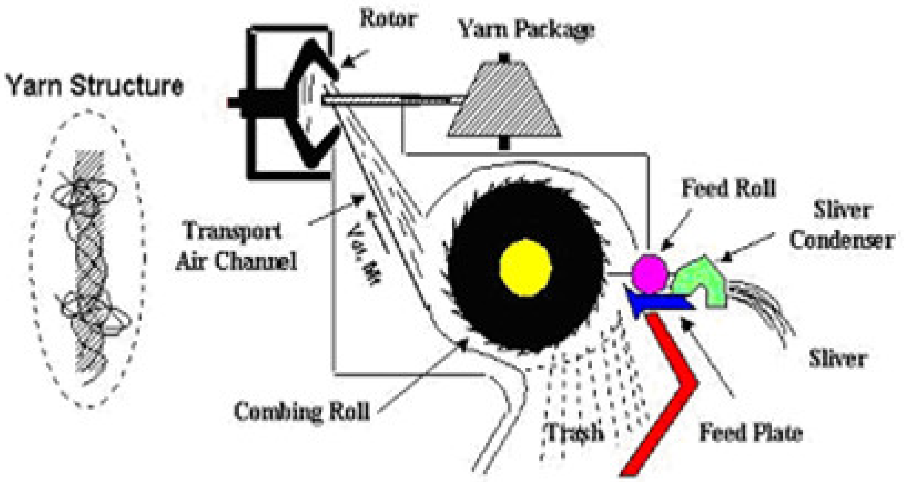
Open End Spinning – Rotor Spinning

https://www.youtube.com/watch?v=UalCnV84SdU **viděno 28.3.2020**

Principle of Open End Spinning

Principle:

A sliver is fed through a sliver guide via a feed roller and feed table to a rapidly rotating opening roller. The rotating teeth of the opening roller comb out the individual fibers from the sliver clamped between feed table and feed roller. After leaving the rotating opening roller, the fibers are fed to the air channel. Centrifugal forces and a vacuum in the rotor housing cause the fibers move via the channel to the inside wall of the rotor.

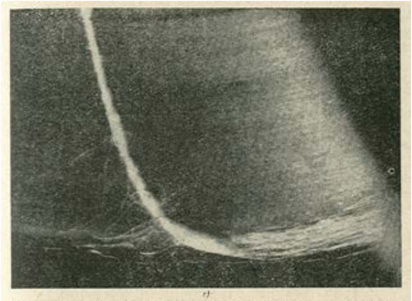


The centrifugal forces in the rapidly rotating rotor cause the fibers to move from the conical rotor wall toward the rotor groove and be collected there to form a fiber ring.

Principle of Open End Spinning

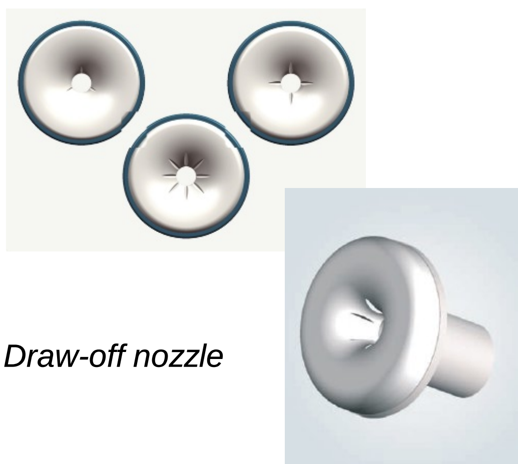
Principle:

To produce yarn, it is necessary to insert free end of yarn made before to the spinning box. When a spun yarn end emerges from the draw-off nozzle into the rotor groove, it receives twist from the rotation of the rotor outside the nozzle, which then continues in the yarn into the interior of the rotor. The yarn end rotates around its axis and continuously twists-in the fibers deposited in the rotor groove, assisted by the nozzle, which acts as a twist retaining element.

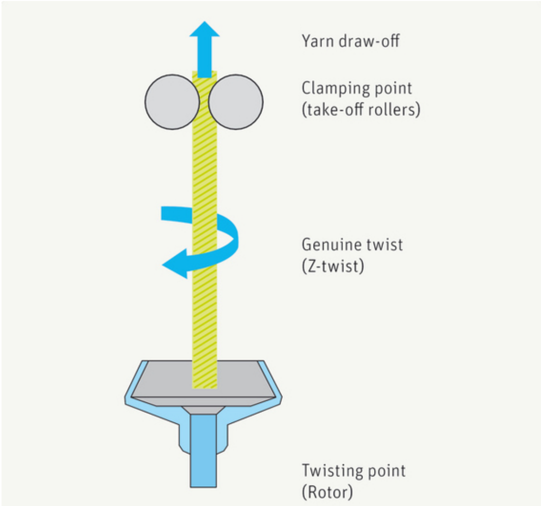


c)

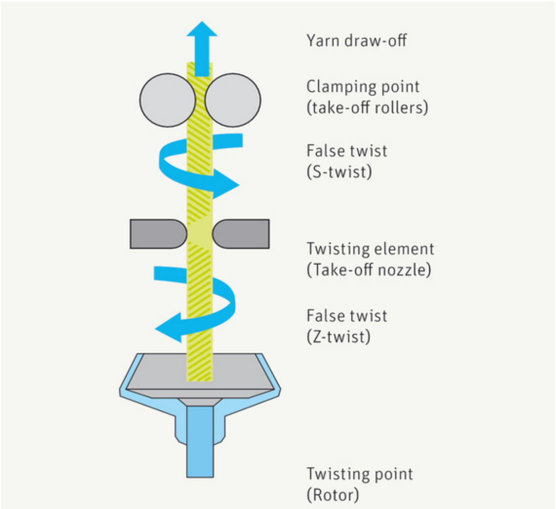
Obr. 6-40 a) Fotografický snímek zakrucování příze ve spřádacím rotoru, b) Fotografický snímek zakrucování s přikrucovanými povrchovými vlákny. c) Fotografický snímek svinování stužky s přikrucováním povrchových vláken



Draw-off nozzle



Imparting twist to the yarn – real twist in the Z direction – due to rotation of rotor



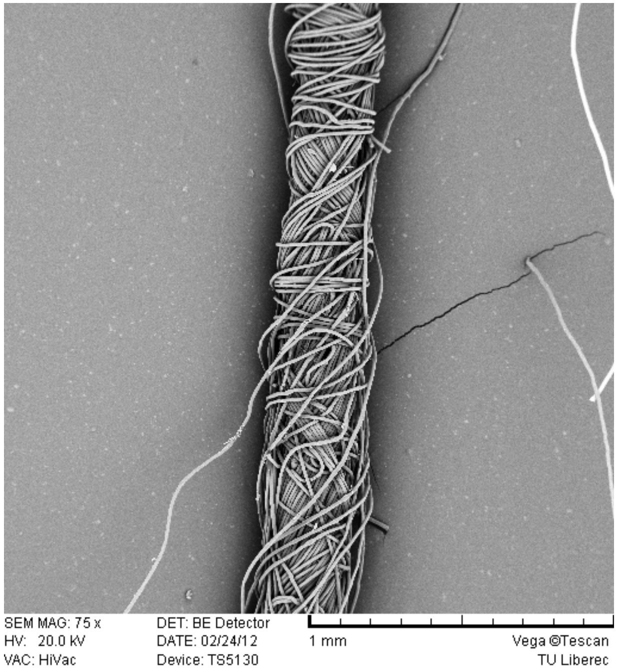
Imparting twist to the yarn – additional twist due to false twist effect in the Z and S direction

The yarn formed in the rotor is continuously taken off by the delivery shaft and the pressure roller through the nozzle and the draw-off tube and wound onto a cross-wound package.

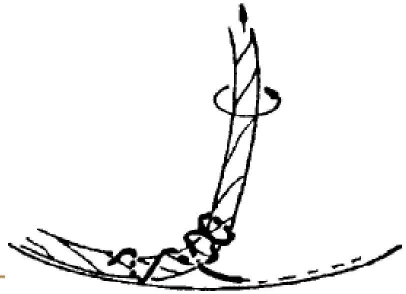
Properties of Rotor Spun Yarn

Compared to the ring spun yarn, rotor spun yarn has:

- **Lower tenacity (about 10 -20 %)**
- **Lower variation of tenacity**
- **Higher elongation**
- ***Lower mass irregularity***
- **Much lower imperfections (yarn faults)**
- **Lower hairiness (about 50%)**
- **Higher yarn bulk**
- **Higher abrasion resistance**
- **Rougher surface**
- **Duller lustre**



Rotor - spun yarns - convoluted structure, fibres on yarn surface layer are only partially twisted compared to fibres in the core. Some fibres are randomly deposited on the yarn surface. Some surface fibres are twisted-in to the yarn body (belt or belly fibres).



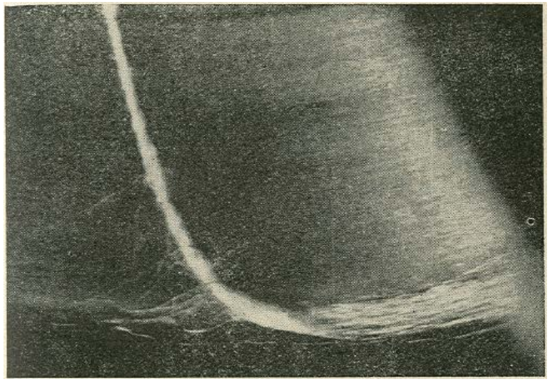


Photo of ribbon twisting with added surface fibers

Rotor spinning machine

Comparison of rotor spun yarns properties with ring spun yarns

In comparison with carded ring spun yarn a rotor spun yarn has:

lower mean relative tenacity - because fibres are less straightened in yarn thus there are lower utilization of fibres strength in yarn

lower variation coefficient of tenacity - because yarn has lower variance of tenacity, but minimum yarn tenacity has the same level as ring spun yarn, therefore lower yarn breakage rate does not occurs

lower mass irregularity than carded ring spun yarn due to back doubling (there are lower value of linear mass irregularity and square mass irregularity - *CV*)

higher elongation
higher yarn bulk
better abrasion resistance
less number of faults
better thermal insulting properties
lower hairiness
better affinity to the dye
rougher surface

Yarn utilization
- comes from yarn properties and from requirements on final product

Ring spun yarns – clothing; dresswear, bed linen
Rotor spun yarn - denim, working clothes, terry towels
…

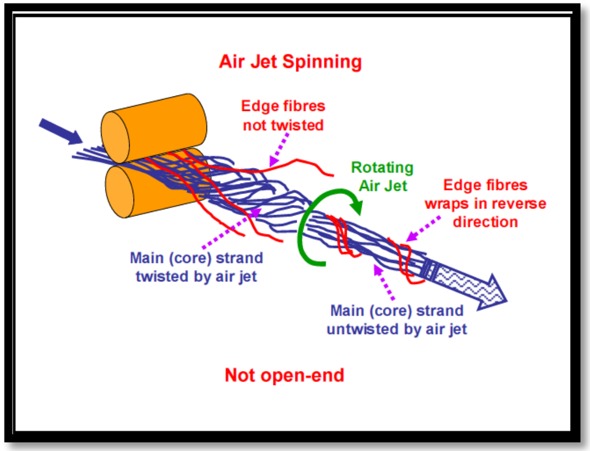
Yarn count higher than 10tex can be produced.

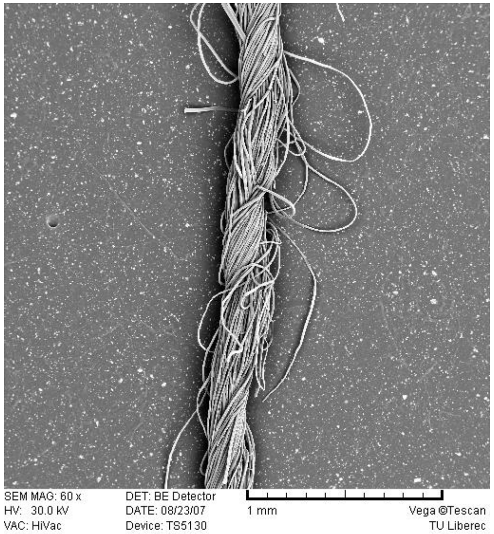
Air-Jet Spinning

The term Air jet spinning is used for spinning technologies where staple fibers are twisted with the use of airstreams.

- The two nozzle air-jet sp. technology – older technology
- <u>The one-nozzle air jet technology </u>– has much more potential, yarn with better properties = today it substitutes two nozzle technology

Ring-spinning is characterized by a continuity in the fiber flow, and rotor spinning is characterized by a complete separation of fibers prior to spinning, air-jet spinning exhibits an intermediate feature in which part of the fiber strand flows continuously and another part is separated.



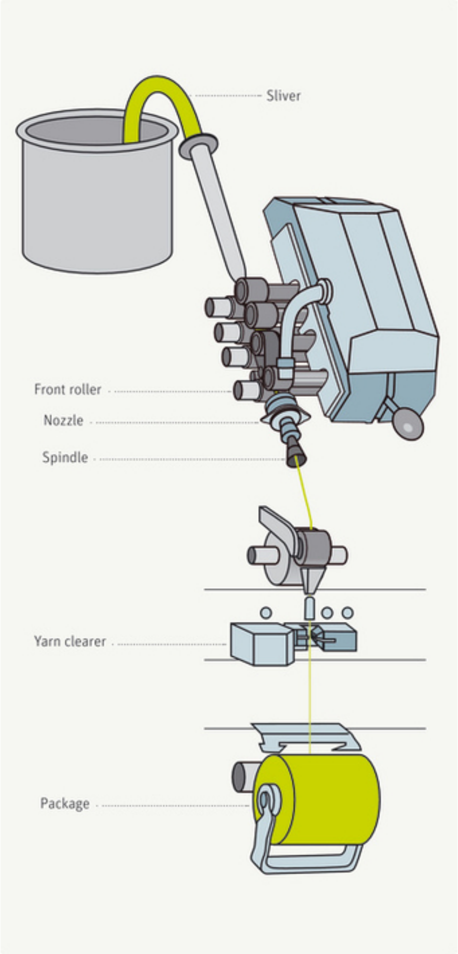


Yarn count range: 8,5 – 30 tex
Processed materials: Cellulosic fibers, 100% combed cotton, 100% PES, blends

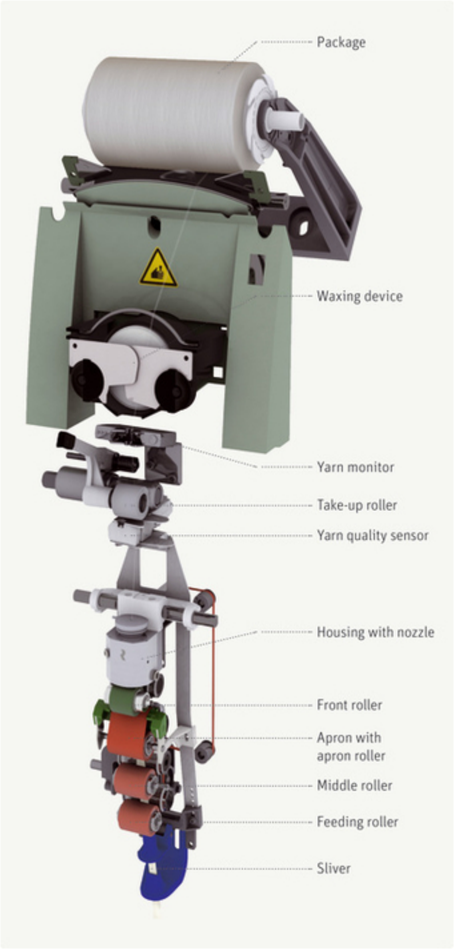
Air Jet Spinning

The one-nozzle air jet technology

Murata Vortex spinning machine
(yarn's trade name Vortex)



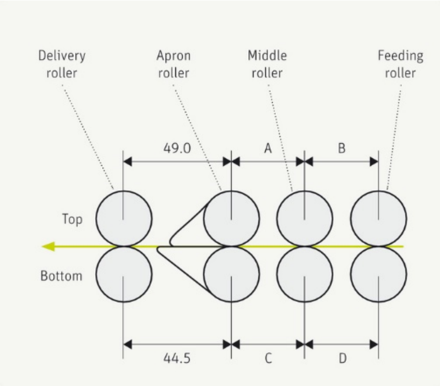
Rieter air-jet spinning machine
(yarn's with trade name Com4®jet)



- Similar principle of yarn production

Air Jet Spinning

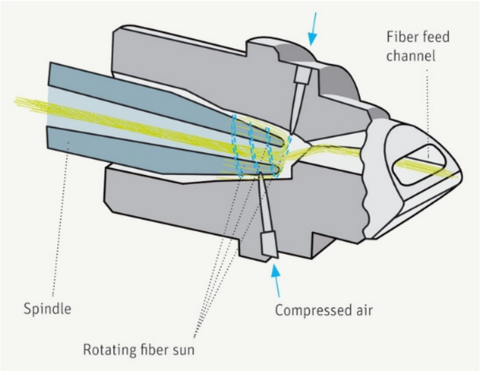
Air Jet Spinning



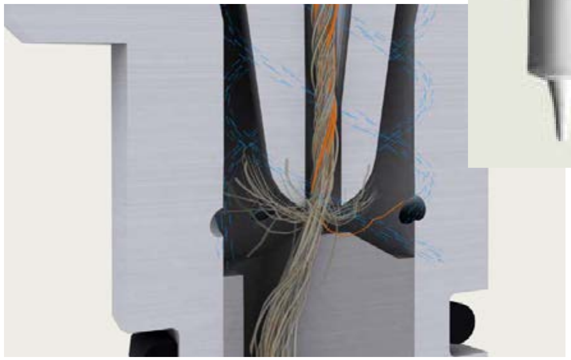
Principle of yarn production:

- The input strand is a drawn sliver. Drafting is achieved using multiple zone roller drafting (4/4) with two aprons .

- Then drafted fibers strand passes through the nozzle housing compound of fiber feed channel, air nozzle holes, spinning tip (hollow spindle).

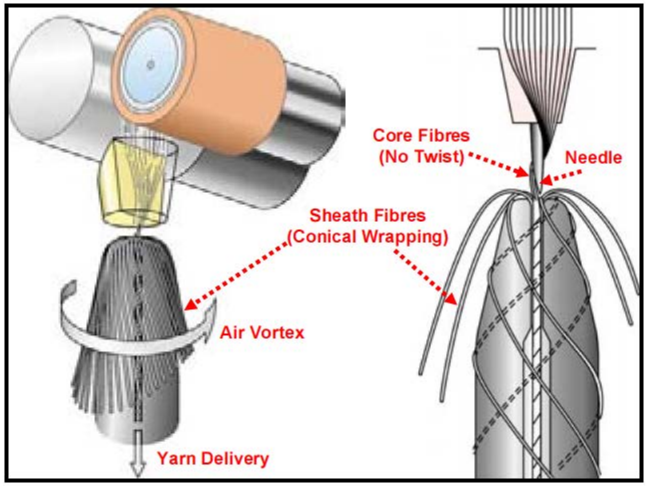


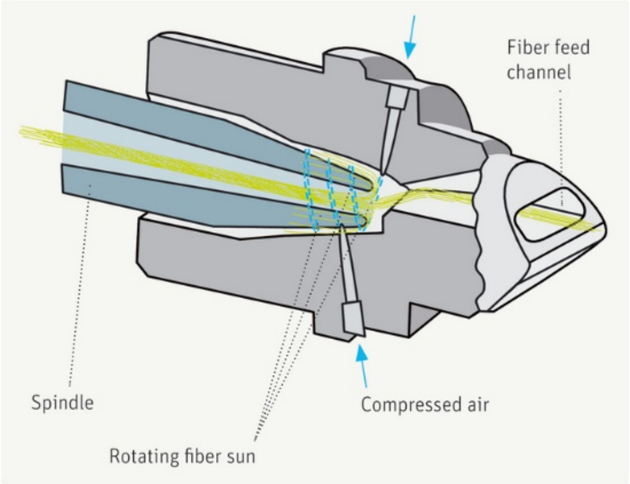
The nozzles in the nozzle block induce swirling air currents (vortex). The air vortex generates a certain vacuum, which results in an air flow through this channel. This air flow transports the fibers from the drafting unit to the spindle entry. By the action of vortex, trailing ends of some fibers are separated from the fiber bundle and thereby twine over the spindle. By the action of vortex air, they are twisted around non-rotating yarn core at the entry of spinning tip (hollow spindle). Inside the spinning tip, yarn formation proccess is finished and yarn is taken-off and wound onto a package.



Air Jet Spinning

- The twist of surface fibers generates a certain torque in the yarn being formed. This torque has tendency to twist fiber bundle between drafting unit and spindle (false twist formation). This must be avoided in order not to interfere with the generation of the necessary free fiber ends – twist stop element- detours the fiber bundle before entering the spindle
- Twist stop element: Murata: needle, Rieter – special fiber feed channel

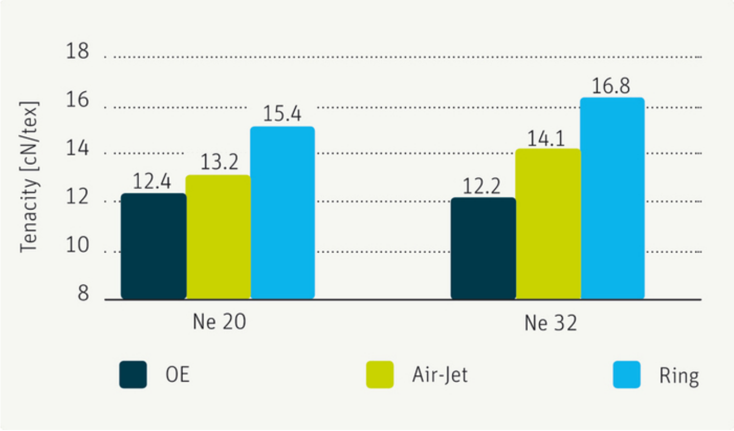




Properties of Vortex /Rieter Air Jet Spun Yarn

Properties of vortex (Rieter air-jet) yarn

- **Yarn strenght is situated between the strength of ring-spun and rotor-spun yarns, the strength of air-jet spun yarns being nearer to rotor-spun yarns for shorter staples, and nearer to ring-spun yarns for longer staples**



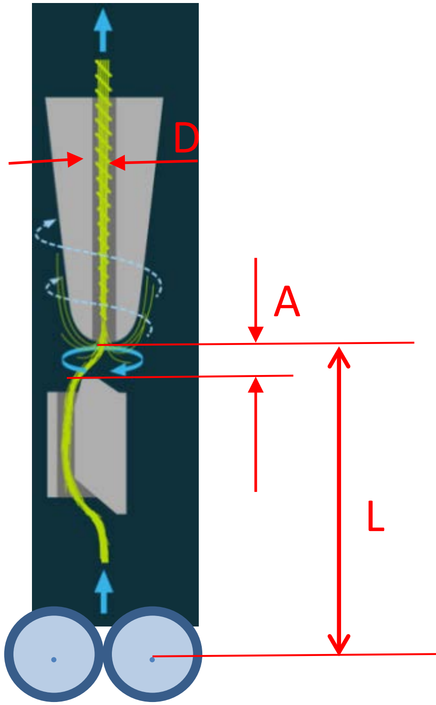
Tenacity of cotton carded air-jet spun yarn by Murata

- Mass evenness values comparable to those of ring-spun yarns (in case of good setting of drafting unit).
- Hairiness is considerably lower than the hairiness of comparable ring-spun and rotor spun yarns.
- Abrasion resistance of air-jet yarns - better than that of ring-spun yarns.
- Low snarling tendency.
- Higher resistance to bending
- Slightly lower covering power

Rieter Air Jet and Vortex Spinning System

<u>The main spinning parameters in air-jet spinning</u>:

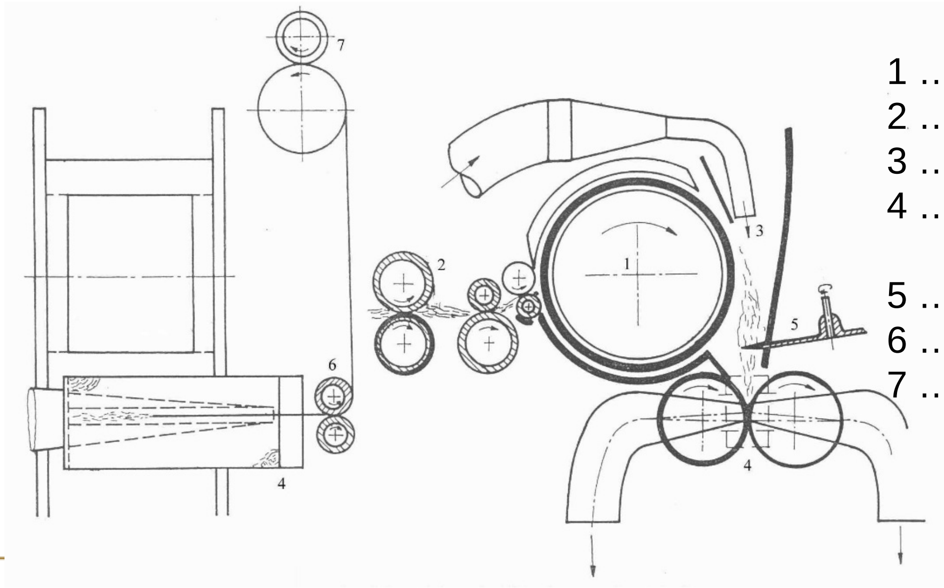
- Yarn delivery speed (up to 500 m/min)
- Nozzle air pressure (4-6 bar)
- Distance between the nip line of the front roller and top of the nozzle tip (L)
- Diameter of spinning tip
- Total Draft ratio
- Construction of nozzle housing
- The spinning draft ratio ($V_{Front\ Roller}/V_{Delivery}$);



Dref Spinning

- Friction mechanical-aerodynamic spinning system
- Dref 2000 or Dref 3000

Dref 2000:
One or more slightly drawn carded slivers are opened by saw-tooth opening roller to individual fibers. Separated fibers are then lifted off the roller by a blower and form a cloud, descending towards two perforated drums. One suction stream per drum draws the fibers into the convergent region between drums. The open end of the yarn projects into this zone and is also sucked towards the perforated drums. Since these rotate, the yarn also rotates in the convergent region. The newly arriving fibers contact the rotating yarn and are thereby caught and twisted in. It is only necessary to withdraw the yarn continuously to twist fibers newly arriving in the convergent region into a yarn. Yarn is delivered by taking-up rollers and then wound onto cross-wound bobbin.

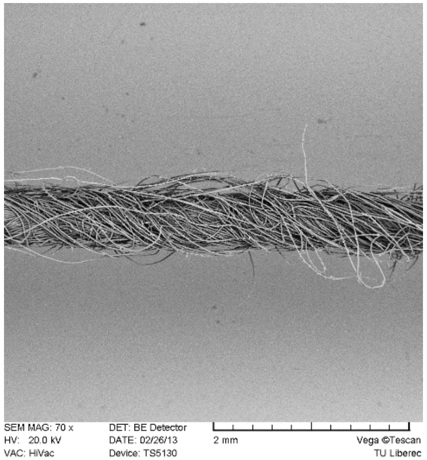


1 … opening roller
2 … drafting arrangement
3 … blower
4 … spinning drums (perforated)
5 … formation disc
6 … taking-up roller
7 … cross-wound bobbin

Yarn count range:
2000 – 40 tex – DREF 2000
666 – 33 tex - DREF 3000

Dref Spinning

- **Suitable for all kinds of fiber material, also for aramid and carbon fibers.** Polyester and polyamide fibers are often used in the core and cotton in the sheat (envelope). Even filaments can be bound into the core to produce core yarns.
- The usable range of fiber linear density is from 0.6 to 10 dtex.
- Yarn count range: 2000 – 40 tex – DREF 2000
- 666 – 33 tex - DREF 3000



- **Dref 3000 yarn structure: fasciated (bundled yarn) – core without twist wrapped with sheat fibers.**

- Yarn have bulky appearance, loopy yarn surface, lower tenacity compare to ring spun and rotor yarn yarn, tenacity of Dref 3000 yarn is influenced by core fibers. The breaking elongation of ring, rotor and friction spun yarns is equal.
- Hairiness of Dref yarns - between ring- spun and rotor spun.
- Yarn irregularity is comparable with carded ring spun yarn.
- Home textiles, sport, leisure clothing, outerwear, technical products