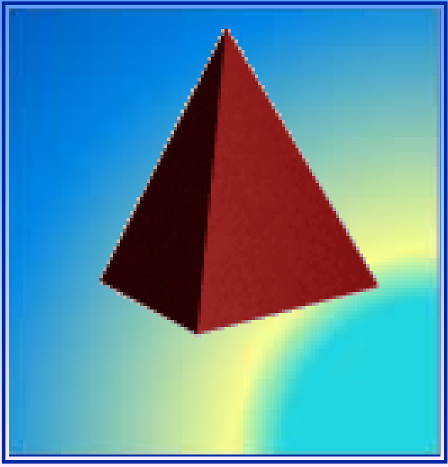
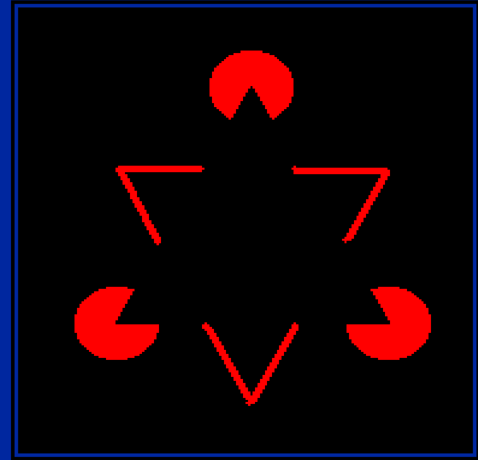
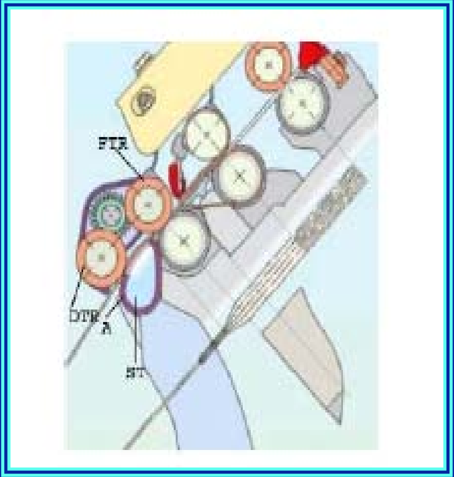
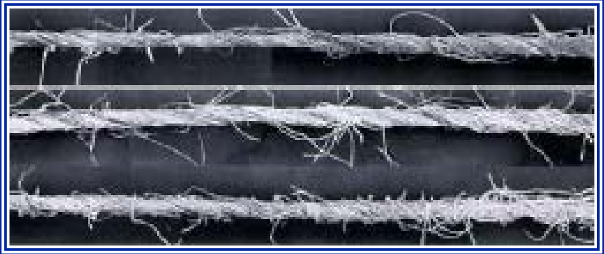
Yarn forming systems

Introduction to short staple yarn production









Introduction

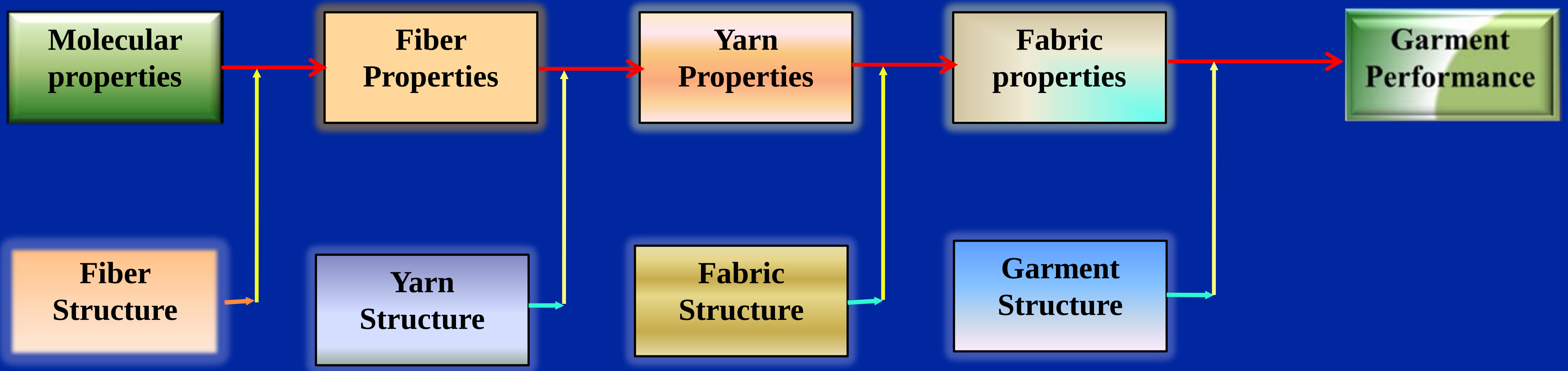
Engineering is an iterative decision-making process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. It is the link between scientific discoveries and commercial applications by applying mathematics and science to research and to develop economical solutions to practical technical problems. *The study of structure and physical properties of fibers, yarns and fabrics are necessarily units to build up a textile technologist.*

Textile products have been designed by trial and error for thousands of years. However, in the last few decades, industrial and academic experts have recognized the importance of systematic engineering design of textiles and textile processes. Technological knowledge (related to material processing) and technical knowledge (related machines) should be integrated together to insure a quality product at reasonable economical level.

The aim of this course is not only transfer of textile technology (know how), but also the technology of thinking (know how to think). This is essential to be able to develop, and create new products. Tools are complete identification of material to transformed to a product, principals of up to date technology, and the functionality of the end-product.

Hierarchical Relationships of Fiber, Yarn, Fabric and Garment to the Performance of Clothing

Fibers are the fundamental and the smallest elements constituting textile materials. **The mechanical functional performance of garments are very much dependent on the fiber mechanical and surface properties, which are largely determined by the constituting polymeric molecules, internal structural features and surface morphological characteristics of individual fibers.** *Scientific understanding and knowledge of the fiber properties and modeling the mechanical behavior of fibers are essential for engineering of clothing and textile products.*



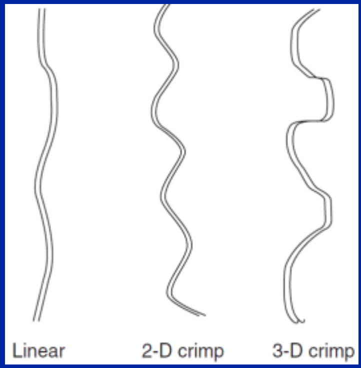
Definition of Fiber Characteristics I

Fiber Morphology

***Fiber morphology*: The morphology of fibers includes macrostructure, microstructure, sub-microscopic structure and fine structure of fibers.**

***Macrostructure:* includes**

a) *Fiber size:* has a very important influence on fiber stiffness, which then affects the stiffness of the fabric made from the fiber and hence the way it drapes and how soft it feels. The fiber stiffness also affects how soft or how prickly the fabric feels when it is worn next to the skin.



Fiber crimp

***b) Fiber length:* fiber length is the most important property of a fiber. Fiber length is critical in processing of fibers and yarns and in the translation of fiber strength to yarn strength. In general, a longer fiber length is preferred.**

Textile fibers are either staple or filament length. Staple fibers range from 2 to 46 cm; filament fibers are of infinite length. All natural fibers except silk are of staple length. Silk and manufactured fibers may be staple or filament fibers.

***c) Fiber crimp:* Crimp refers to waves, bends, twists or curls along the fiber length. It is Expressed as Crimps per unit length. Some natural fibers are linear, others form two- Dimensional or three- dimensional crimps as shown in the Figure. Crimped fibers tend to have higher elongation than linear fibers.**

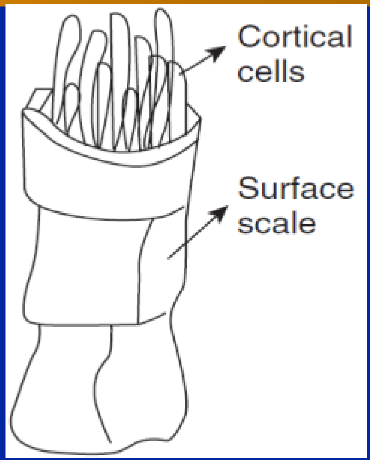
***Microstructure of fibers:* includes their surface contour and cross-sectional shape. Cross-sectional shape refers to the shape of a horizontally cut fiber section. It may be round, triangular, dog-bone, kidney-bean, fl at, and so on. The shape of a fiber's cross-section is important in many applications. It has influence on bending stiffness and torsional stiffness of the fiber. cotton, offer the least resistance to bending.**

Definition of Fiber Characteristics II

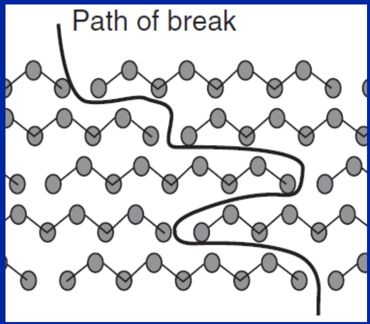
Fiber Morphology

Submicroscopic structure: details of fibers on the surface, as well as in the inner side, are observable. The figure shows the schematic microscopic structure of wool fiber.

Fine structure: All fibers are assemblies of macromolecules, called polymers, in the form of hundreds or even thousands of individual chemical units, covalently bonded together one after the other as illustrated in the figure. Fine structure describes the length, width, shape, and chemical composition of these polymers. It largely determines the ability of a fiber to withstand mechanical forces. There are three types of polymers comprising textile fibers: **homo-polymers, copolymers, and block polymers**. In **homo-polymers**, the most common type, one monomer (one chemical compound) repeats itself along the polymer chain. In **copolymers**, two or more monomers comprise the polymer chain. In **block polymers**, blocks comprised of homo-polymers are repeated along the polymer chain. **Polymer length** is specified as the number of times the monomer is repeated along the chain, called the **degree of polymerization**. Polymer length plays a role in fiber tensile properties.



Wool submicroscopic structure



Fine structure of fibers

Definition of Fiber Characteristics III

(Mechanical behavior – Tensile properties)

Mechanical behavior: **The mechanical properties of fibers are their responses to applied forces and to recovery from those forces. They contribute both to the behavior of fibers in processing to yarns and to the properties of the final products so that a knowledge of fiber behavior is essential to an understanding of yarn mechanics and fabrics mechanics.**

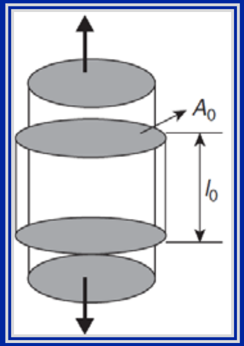
Tensile properties:

Stress–strain curve: **Because of the linear shape of a fiber, the tensile properties (the behavior under forces and deformations applied along the fiber axially) are the most important properties and are the most studied. The figure illustrates the tensile deformation. In general engineering, the tensile stress = force/area, $\sigma = F / A_o$;**

the tensile strain = change in length/original **length, $\varepsilon = \Delta l / lo$.**

In textile technology, a specific stress is often used instead of the general stress used in engineering area:

Specific stress (Tenacity) = force/linear density, $\sigma = F/T$.

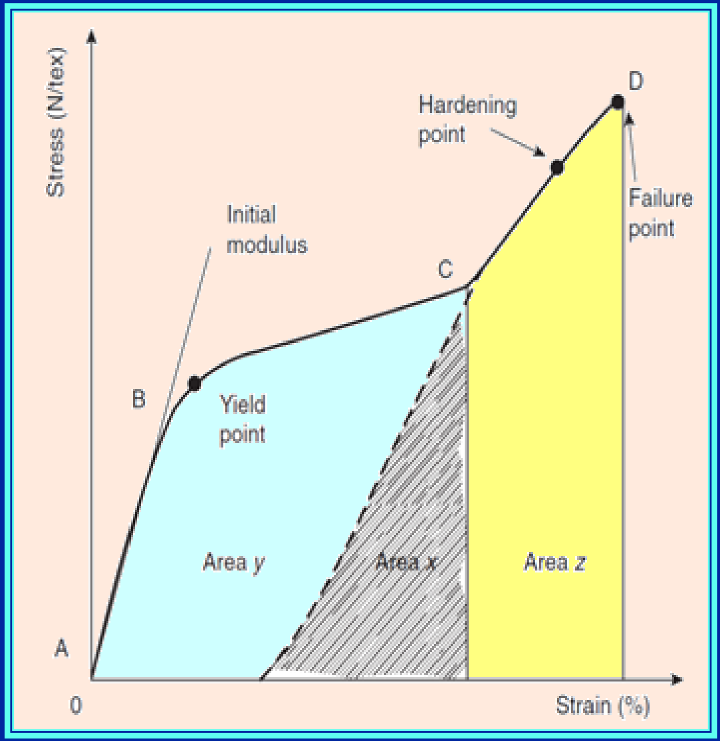


Schematic tensile deformation

Definition of Fiber Characteristics IV
(Mechanical behavior – Elasticity, work of rupture)

The figure shows a model stress–strain curve. The curve begins with a straight-line segment that rises as stress is increased (AB) and then suddenly flattens and rises at a slower rate (BC). Close to the failure point, the curve rises steeply (CD). The details of each of the regions is addressed as follows:

In region AB, the deformation is a result of bond stretching and flexing. It is completely reversible. Hooke's law is obeyed : $\sigma = E\varepsilon$ *where* *E* is the slope of the line, called Young's modulus. As the fiber extends along the axial direction, it contracts laterally. Poisson's ratio, defined as the ratio of lateral contraction to axial extension, is another important material characteristic that deals with the behavior in the elastic region. After the yield point, deformation becomes nonlinear, and it is usually plastic.



Stress-Strain curve

Definition of Fiber Characteristics V

(Mechanical behavior – Elasticity, Resilience and Creep)

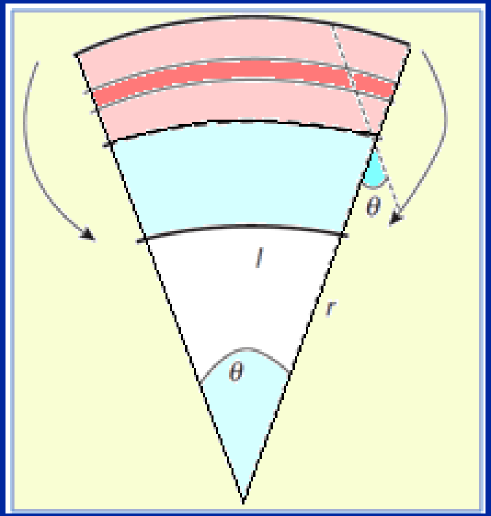
Resilience: **The resilience, also called work of recovery, of a fiber is the ratio of energy returned to energy absorbed when a fiber is deformed and then released. It may be extensional, flexural, compressional, or torsional. In the figure, the fiber resilience of extension is the ratio of area *x to area x + y.***

Creep and stress relaxation **are the tests developed to probe their time-dependent behavior. In the creep test, the strain increases with time in a sample under constant load. In the stress relaxation test, the stress decays with time after the sample is given an instantaneous strain. *Moisture* also affects the mechanical behaviors of fibers. Basically, the moisture lodges in the non-crystalline regions and plasticizes them, reducing the modulus.**

Bending: When a fiber is bent, **the under curvature will compress; those on the upper curvature will extend; and those on the center plane will be unchanged in length. Flexural rigidity (resistance to bending, stiffness) of a fiber is defined as the couple required to bend the fiber to unit curvature. The flexural rigidity can be expressed in terms of the Young's modulus *E as:***

$$B = \frac{1}{4\pi}\frac{\eta E T^2}{\rho}$$

where, η is a shape factor related to the cross-section of the fiber, ρ and *T are the density and linear density respectively.*



Bending of a fiber.

Definition of Fiber Characteristics VI

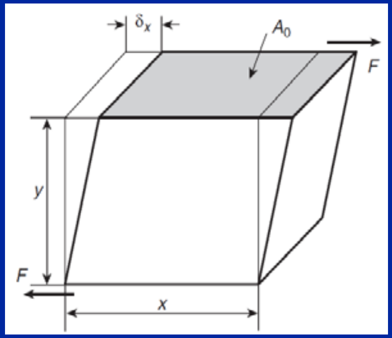
(Mechanical behavior –shear, compression)

The specific flexural rigidity, R_f is *equal to the flexure* rigidity of a filament of unit tex

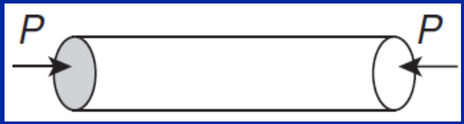
$$R_f = \frac{1}{4\pi} \cdot \frac{\eta E}{\rho}$$

Shear and torsion: the figure shows the shear deformation of a solid cube unit. The shear stress τ is expressed as ***F/A0 and the shear strain is calculated*** as ***δx/y. Then, in the elastic region, the shear modulus G can be defined as*** the ratio of shear stress to shear strain: **G =** γ / τ **.**

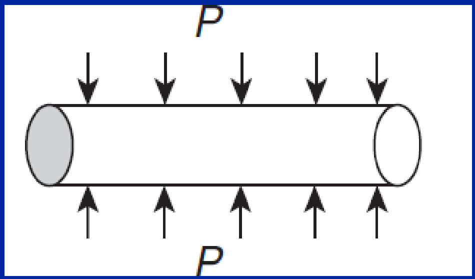
Compression: The figure shows a cylinder under axial compression. A compression stress is simply negative to tensile stress and a compression strain is also a negative one. The initial compressive modulus is generally the same as the initial tensile modulus. However, as the compression force increasing, the fiber will buckle easily.



Shear deformation of a cube.



Axial compression of a cylinder



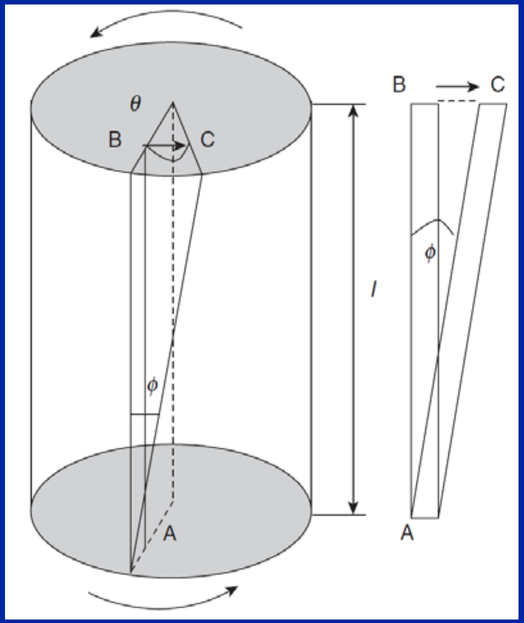
Transverse compression

Definition of Fiber Characteristics VII

(Mechanical behavior – Torsion, and friction)

The torsional rigidity: The figure shows the twisting deformation of a fiber of circular cross-section. If we look at a small region, the fiber is sheared. The torsional rigidity of a fiber, its resistance to twisting, is defined as the couple needed to achieve unit angular deflection between the ends of a specimen of unit length. Usually the specific torsional rigidity, R_t *the torsional rigidity of a* specimen of unit linear density (in tex), independent of the fineness of the particular specimen, is used. the bending rigidity can be obtained in terms of the Young's modulus: $R_t = \eta n / \rho$ *Here,* ρ *and* η *are the* density and the shape factor of the fiber respectively and ***n*** shear modulus and expressing the twist per unit length, $\tau = (1/2\pi)\phi / l$.

Fiber friction is the force that holds together the fiber in a spun yarn and the interlacing threads in a fabric. Here, high friction is an advantage to enable a greater proportion of the strength of the individual fibers to be obtained. However, lower friction of a fiber may be desired in other cases, such as in minimizing wear of fibers and fabrics, providing good fabric drape, and so on. Friction coefficient, μ , is used to denote the friction property of a fiber.



Shear or torsion on a cylinder.

Basics of yarn forming

Basics for developing an understanding of spinning process:

Today, Yarn production is highly advanced technology that facilitates the engineering of different yarn structures having specific properties for particular application in garments, household, carpets, sport clothing, fabrics for automotive interiors, aerospace and healthcare applications.

Yarn classification and structure:

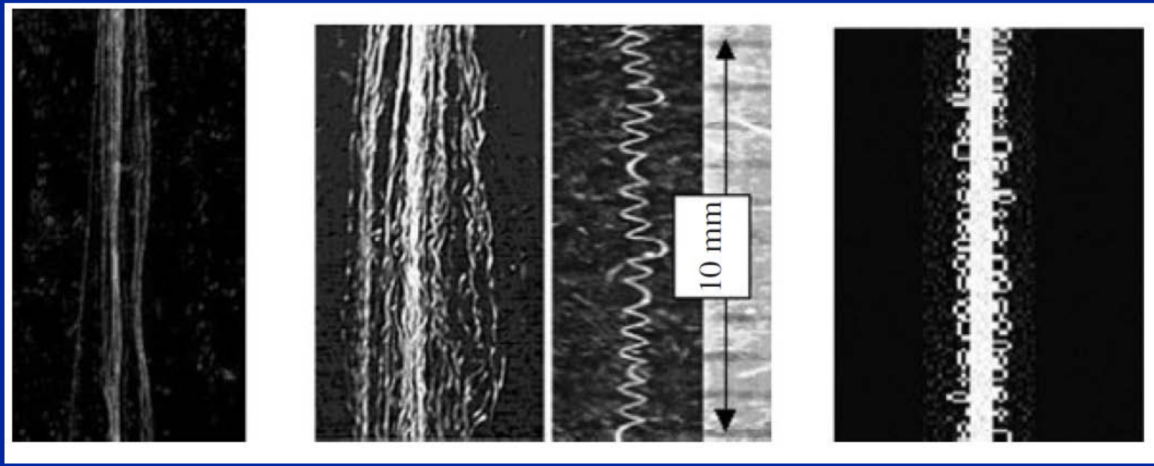
Yarns may be classified into four main groups:

- **Continuous filament yarns**
- **Staple spun yarns**
- **Composite yarns**
- **Plied yarns**

Yarn Classification

Group	Sub-group	Examples
Continuous filament yarns	Untextured (flat)	Twisted, Interlaced, Tape.
	Textured	False twisted, Stuffer box crimp Bi-component, Air-jet.
Staple Spun Yarns	Non-effect/Plain Or (Conventional)	Carded, Combed Ring Spun, Worsted, Semi-worsted, Woolen.
	Non-effect/Plain (Unconventional)	Rotor, Compact, Air-jet, Vortex, Friction, Hollow-spindle wrap, 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

Production Chain of Garment Production



Un-textured Textured | False Twist Textured Continuous Filament Yarns | Air-jet

Choice of Fiber

(natural,Manmade, or blends

Criteria: Softness, Easy care, etc.

Yarn Forming

Yarn Structure

(Plain, Fancy, Plied)

Fabric Forming

Fabric Structure

(Weave: Plain, Twill, etc)

(knit: Single or double Jersey, etc.)

Fully Fashioned

Finished Fabric

(Cotton, worsted, Woolen, etc.)

Garment Production

Production of a particular end use fabric:

Choose type of Fibers

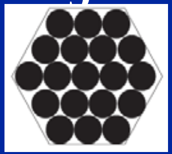
Spinning into a yarn structure of specified properties

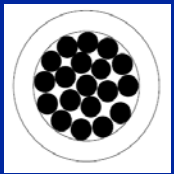
Woven or knitted structure give the desired fabric aesthetic and/or technical performance

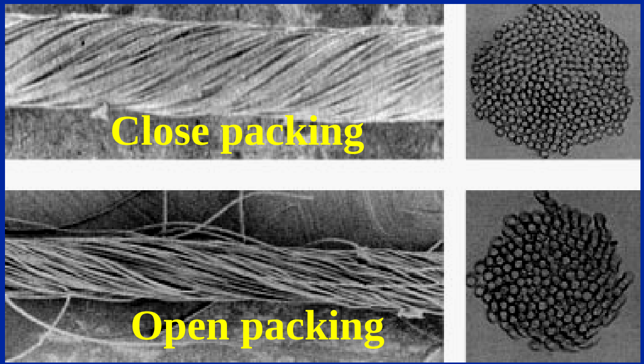
Nonwoven is also widely used for technical and industrial purposes.

Definition of Staple Yarn

- **The following three characteristics are evident:**
- **1. A linear assembly of fibers. The assembly could be of any thickness**
- **2.The fibers are held together by twist. However, other means may be used to achieve cohesion**
- **3.There is a tendency for fibers to lie in parallel along the twist spiral.**
- ***A staple-spun yarn is a linear assembly of fibers, held together, usually by the insertion of twist, to form a continuous strand, small in cross section but of any specified length; it is used for interlacing in processes such as knitting, weaving, and sewing.***
- **The Simple Helix Model**
- **The manner in which fibers are packed together in the yarn cross section is important to the effect of frictional contact between fibers on yarn properties.**
- **Two types of packing have therefore been proposed:**







- ***Close packing, which gives a hexagonal arrangement of the fibers in the yarn cross section, and open packing, where the fibers are considered to be arranged in concentric circles of increasing radii. The basic helix model assumes an open packing configuration***

Basic Analysis of Yarn Structure

Assumptions for helical structure

-Yarn composed of a large number of fibers

-The yarn structure consists of a central fiber lying straight along the yarn axis and surrounded by successive, concentric cylindrical layers of increased radii

-The fibers in each layer are helically twisted around preceding layers

-The helix angle of twist gradually increases with radius from 0 for central fiber to α for surface fiber

-All fibers in a given layer have the same angle of twist

-By convention the yarn twist angle is α

-The turns per unit length is constant throughout the yarn

-The fiber packing density is constant throughout the yarn

-At 90 degree cross section to the yarn axis shows the yarn and fibers to be circular and the fibers cross sections lying in filled concentric circular layers

Geometrical equations

$$h = t^{-1}$$

$$l^2 = h^2 + 4\pi r^2$$

$$L^2 = h^2 + 4\pi R^2$$

$$\tan\theta = 2\pi r / h$$

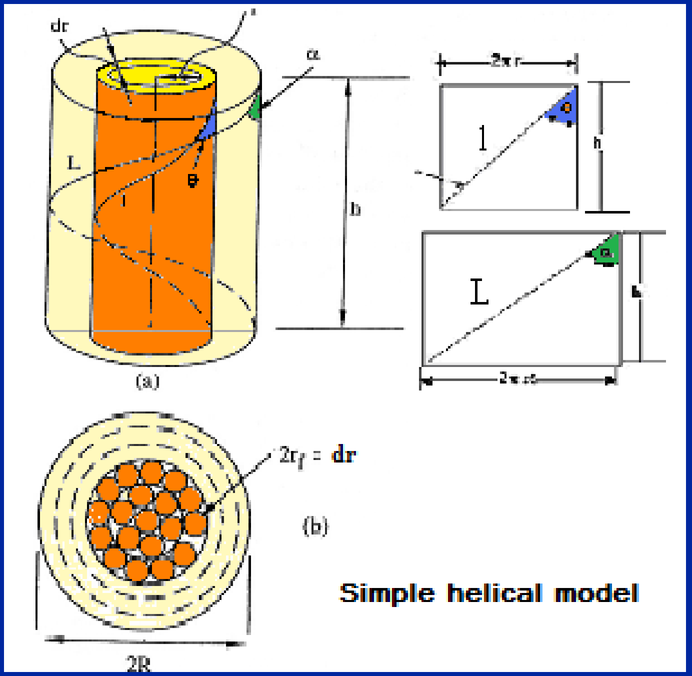
$$\tan\alpha = 2\pi R / h$$

$$R = (2n-1) r_f$$

$$m = \frac{180}{\sin^{-1}\left[\frac{1}{2(n-1)}\right]}$$

m = the number of fibers in the nth layer

The Simple Helix Model



$$TM = \frac{\tan\alpha\sqrt{\rho}}{K_o} = T\sqrt{mass/unit\ length}$$

or TM= TPC$\sqrt{\text{tex}}$ or TM= $\frac{\text{TPI}}{\sqrt{\text{Ne}}}$

n = nth fiber layer,

Limitations of Basic Helical Model

•Many fibers do not have circular cross section. The circular fibers in cross section appear to be elliptical due to their inclination at the helix angle of twist. Nerveless fiber diameter is very small and generally tend sufficiently towards circular and the model remain useful.

The concentric circular layers in the yarn cross section are filled with fibers in contact with each other, accordingly, the number of fibers in the yarn cross section m comprises the arithmetic sum of fibers in the N layers, This is not always true. The outer layer become partially filled, and the yarn radius R is not completely defined. Practically, the partially filled outer layer may not give too great error.

•The model does not take in consideration the projected fibers from yarn body (yarn hairiness). Thus, these fibers move across some layers. Actually some fibers at the yarn surface must have part of their length within the yarn body to hold the tarn together. The fibers in the yarn are interlaced (this is known as fiber migration). Under applying axial force, self locking mechanism is taken place, but some fibers will slide, where some other will brake.

YARN COUNT 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**
- The linear density is defined as the mass per unit length. In System International (SI)units, the mass is in grams, and the unit length is meters.
- ***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.*
- •**Indirect system.** This gives the **length that weighs a standard mass**. The standard mass is either 1 kg or 1 lb, and the associated length is, respectively, in meters or yards
- **The standard length** can be 1 km, 840 yd, 560 yd, or 256 yd. The standard lengths in yards are commonly called **hanks**, or some cases s**keins**.
- **We can now say that the indirect system gives the number of kilometers that weigh a kilogram (metric units) or the number of hanks that weigh one pound (English Imperial units).**
- For carded and combed 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 yarns.

Conversion between yarn numbering systems

Conversion Formulas for the various numbering systems					
convert into / known	tex	decitex (dtex)	denier (den)	Metric No. (Nm)	English Cotton No. (Ne)
tex		10 x tex	9 x tex	1000/tex	591/tex
decitex (dtex)	dtex/10		0.9 x dtex	10000/dtex	5910/dtex
denier (den)	den/9	den/0.9		9000/den	5314/den
Metric No. (Nm)	1000/Nm	10000/Nm	9000/Nm		0.59 x Nm
English Cotton No. (Ne)	591/Ne	5910/Ne	5314/Ne	Ne x 1.69	

With reference to the yarn helix model, the yarn diameter is related to the count as follows:

$$T_t = \frac{1000\pi d_y^2}{4\delta_y}$$

Where δ_y *= the specific volume in g/m3*

T_t *and* δ_y *can be measured, and* d_y *can be calculated.*

Term	Definition
Basic Tex Unit [tex]	Mass of yarn in grams per 1000 meters length
Decimal fraction	Mass of yarn in grams per 10'000 meters length
Decitex [dtex]	1 g / 10'000 m = 1/10 tex Decitex is the count grading for filament and spinning yarns recognized by all international bodies in the man-made fibres industry.
Decimal multiple	Mass in kilograms per 1000 meters length.
Kilotex [ktex]	1 kg / 1000 m = 1000 tex) Kilotex is used to state the counts of spinning tow and similar semi-finished and finished products.

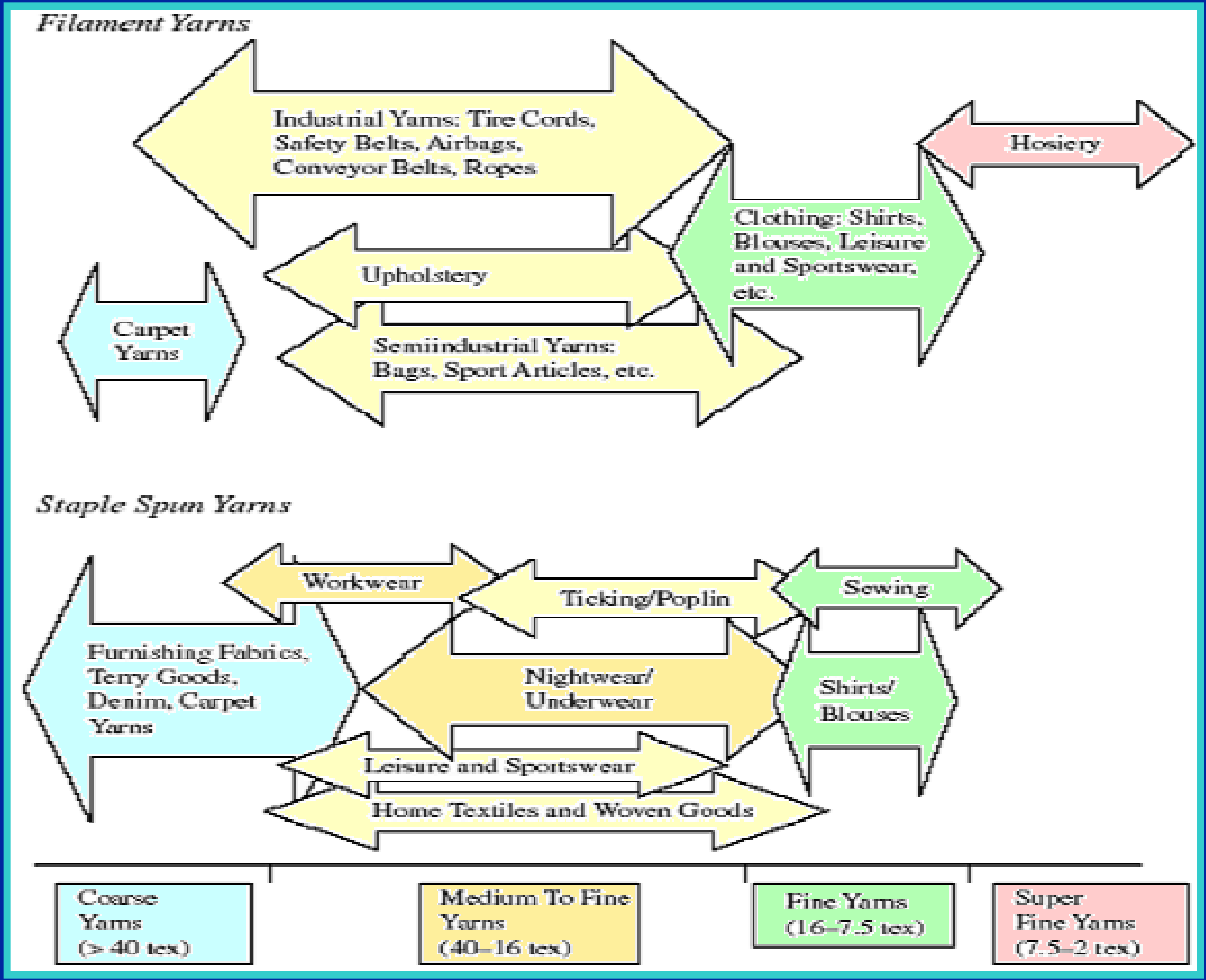
Link to net

Yarn numbering system and conversions.htm

Other numbering Systems	
Count denier [den]	Mass of yarn in grams for length of 9000 meters
Metric yarns number [Nm]	Length in meters per 1 gram of mass
English cotton yarn number [Ne or ECC)]	Number of 840 yards strands per 1 English pound of mass
Wool runs	Number of 1600 yards strands per 1 English pound of mass
Wool, worsted (NeK)	Number of 560 yards strands per 1 English pound of mass
Wool, woolen measure (NeS)	Number of 256 yards strands per 1 English pound of mass
Linen Count (NeL or Lea)	Number of 300 yards strands per 1 English pound of mass
Spun Silk	Number of 840 yards strands per 1 English pound of mass

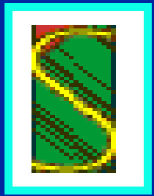
Count range of product areas for continuous filament and spun yarns

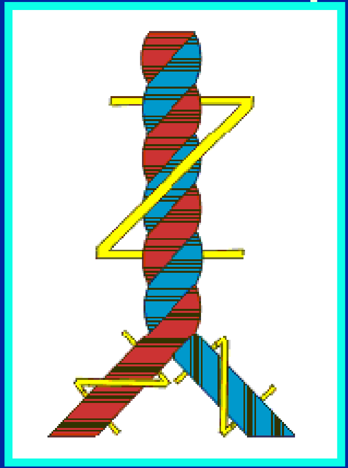
Yarn counts of 2to 7.5 tex for hosiery, staple fibers and continuous filament have quite similar market area. Fine to medium yarn counts 7.5 to 40 tex, are largely used to make textiles for apparel. Spun yarns hold a principle position in the market for shirts. blouse, home textiles, bed linen, trousers, suits, etc. Filament yarns are highly competitive in carpets and sportswear sector and in technical textiles.

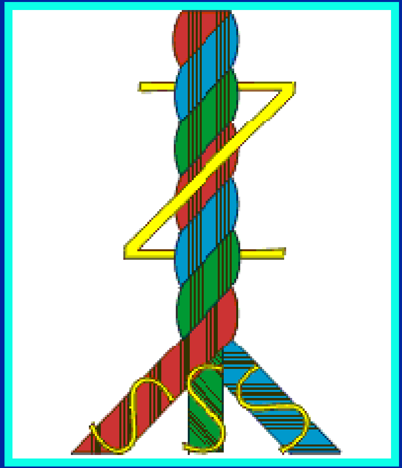


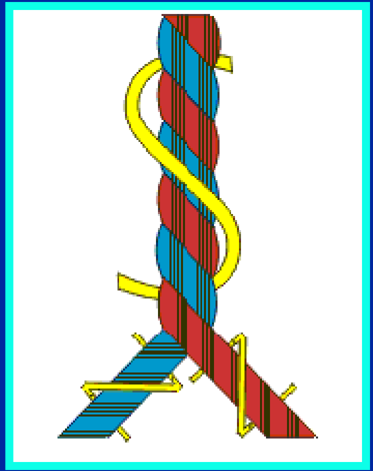
Twist and Twist Factor

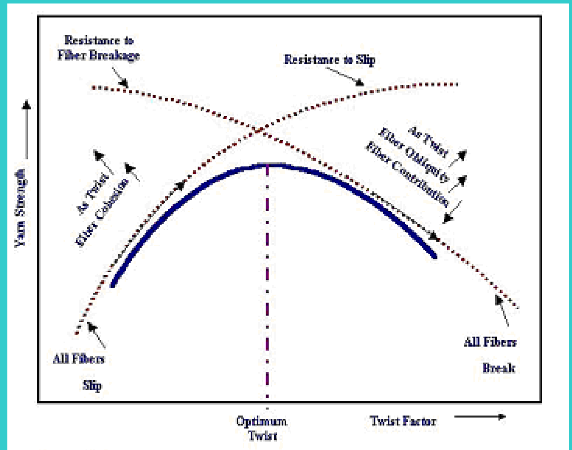
1. **Direction of Twist**
2. **Twist Angle**
3. **Twist Level (degree of twist or twist intensity)**
4. **Twist Multiplier.**











Interpretation of Strength-Twist Relationship

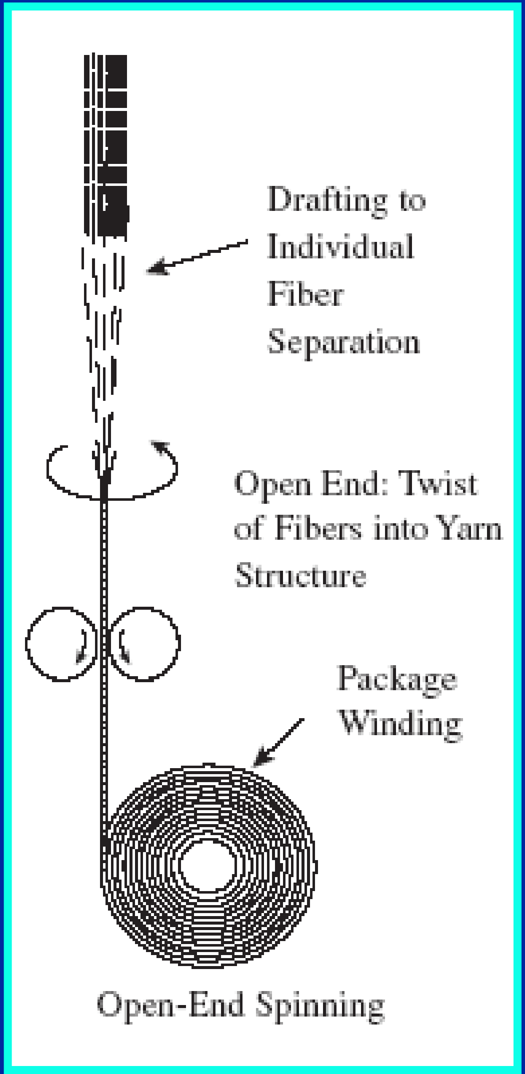
$$\text{Count}_{\text{plied}} = \text{Count}_1 + \text{Count}_2$$

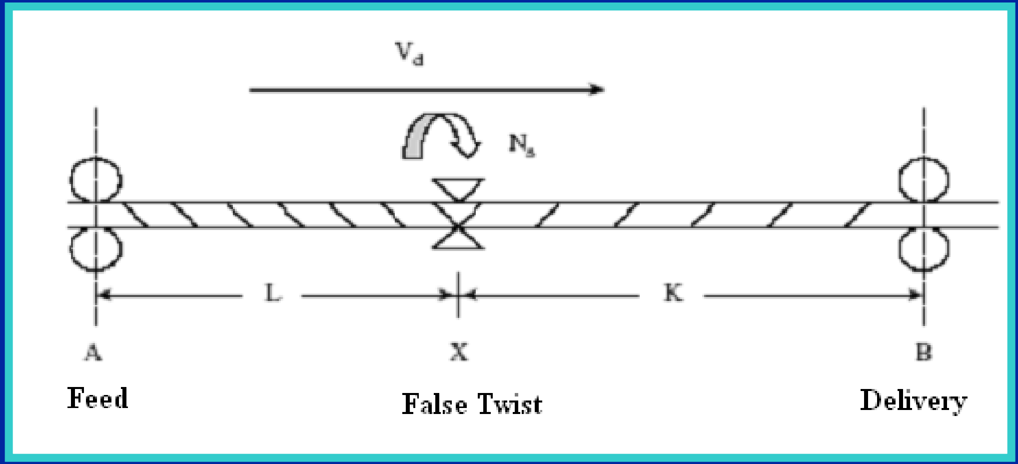
$$\text{tex}_{\text{plied}} = \text{tex}_1 + \text{tex}_2$$

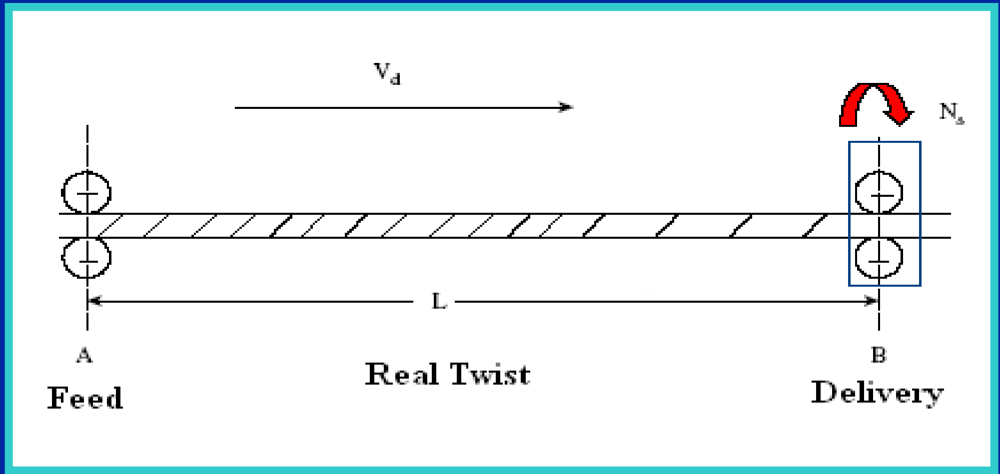
$$\frac{1}{count_{plied}} = \frac{1}{count_1} + \frac{1}{count_2}$$

$$\frac{1}{N_{plied}} = \frac{1}{N_{e1}} + \frac{1}{N_{e2}}$$

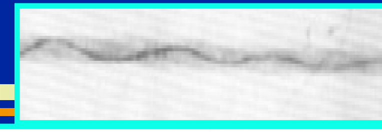
Principle of Twist Insertion Systems





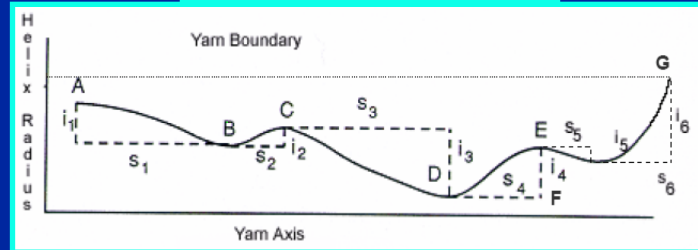


Fiber migration



The idea that staple yarns have **self-locking structures** is attributed to Pierce and Morton. Essentially, a self-locking structure is achieved by fiber lengths meandering

from the outer to the inner regions of a yarn, throughout the yarn length, as they are twisted to lie along the helix angle. In this way, fibers become interlaced to give the spun yarn cohesion. This action is called ***fiber migration***. Migration also occurs in twisted filament yarns.



Definition: **Fiber migration is the cyclic change in the distance of elements of a fiber or filament (along its length) from the axis of a yarn, which occurs during production of the yarn.**

Hearle used the variable (r/R)2 as a relative measure of the radial positions of points along the length of a fiber within the yarn, with respect to the yarn axis (z). A plot of (r/R)2against the corresponding distances along z gives what is termed the migration envelope, and the degree of migration may be quantified by the parameters given in Table

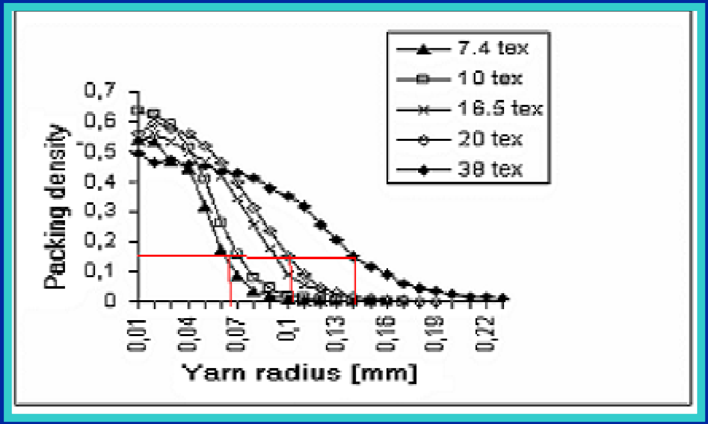
Fiber Migration Parameters

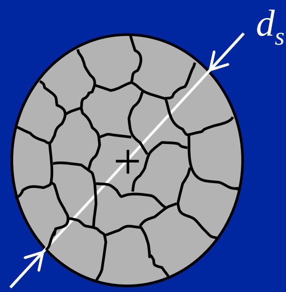
Migration parameter	Migration equation
Mean fiber position	$Y_m = \frac{1}{Z_n}\int Y\,dz$ $= \sum \frac{Y}{n}$ where n is the number of measured positions over a yarn length Z_n
Root mean squared (rms) deviation	$D = \left[\frac{1}{Z_n}\int (Y - Y_m)^2 dz\right]^{\frac{1}{2}}$ $= \left[\frac{\sum (Y - Y_m)^2}{n}\right]^{\frac{1}{2}}$
Mean migration intensity (the rate of migration given by the slope of the migration envelope)	$I = \left[\frac{1}{Z_n}\int \left(\frac{dY}{dz}\right)^2 dz\right]^{\frac{1}{2}}$
Equivalent migration frequency	

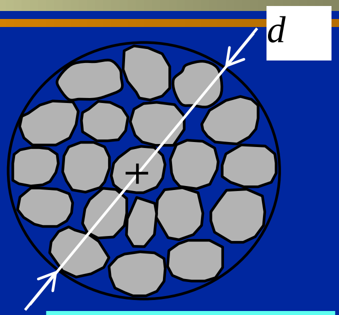
Yarn Packing Density

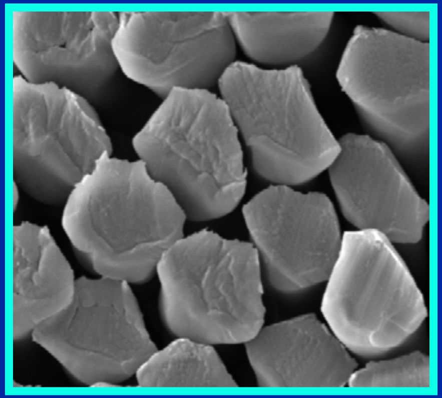
- **Yarn packing density is defined as ratio of the cross sectional area of the fiber to the cross sectional area of yarn. The compactness (radial pressure) of fibers influence the yarn properties. Due to different yarn forming systems, the packing density varies from the yarn center towards the surface, this is known as radial packing density.**
- **The system of annular rings centered on yarn axis (yarn center of gravity) is used. The packing density is then expressed as function of distance from yarn axis. Local packing density is expressed as the ratio of the fibers cross sectional area in annular ring to the total area of annular ring.**

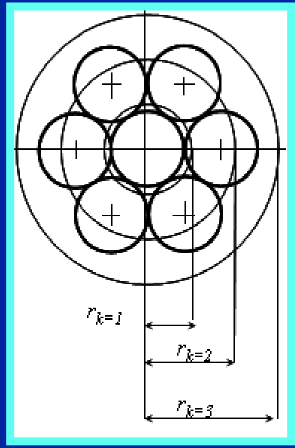
Packing density of cotton yarns











Typical yarn cross-section

Original image

Yarn Diameter and Yarn Hairiness

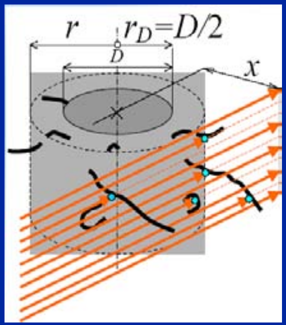
B/W Threshold Image

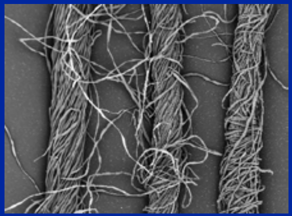
Repaired Image

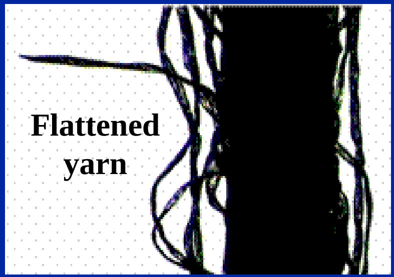
Yarn Diameter: Yarn diameter is an intuitive expression. It is often defined by a diameter of imaginary cylinder where fibers are concentrated. Experimentally determined yarn diameter is denoted as effective yarn diameter. It can be estimated for example from a value corresponding to 0.15 of the mean radial packing density or from the value corresponding to 50% of the so-called blackness or hairiness function. Yarn diameter is given by ,

where T is yarn tex and μ is the packing density.

$$d = \sqrt{4T/\pi\mu\rho}$$

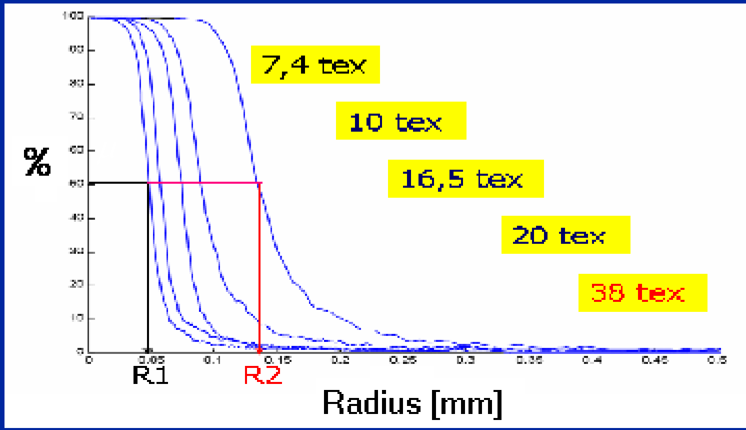






Yarn hairiness: can be evaluated from yarn longitudinal images. This method is based on the registration of light rays passing through yarn body and creation of so-called darkness density traces. The main problem is exact definition of yarn diameter as dividing line between yarn body and hairiness area.

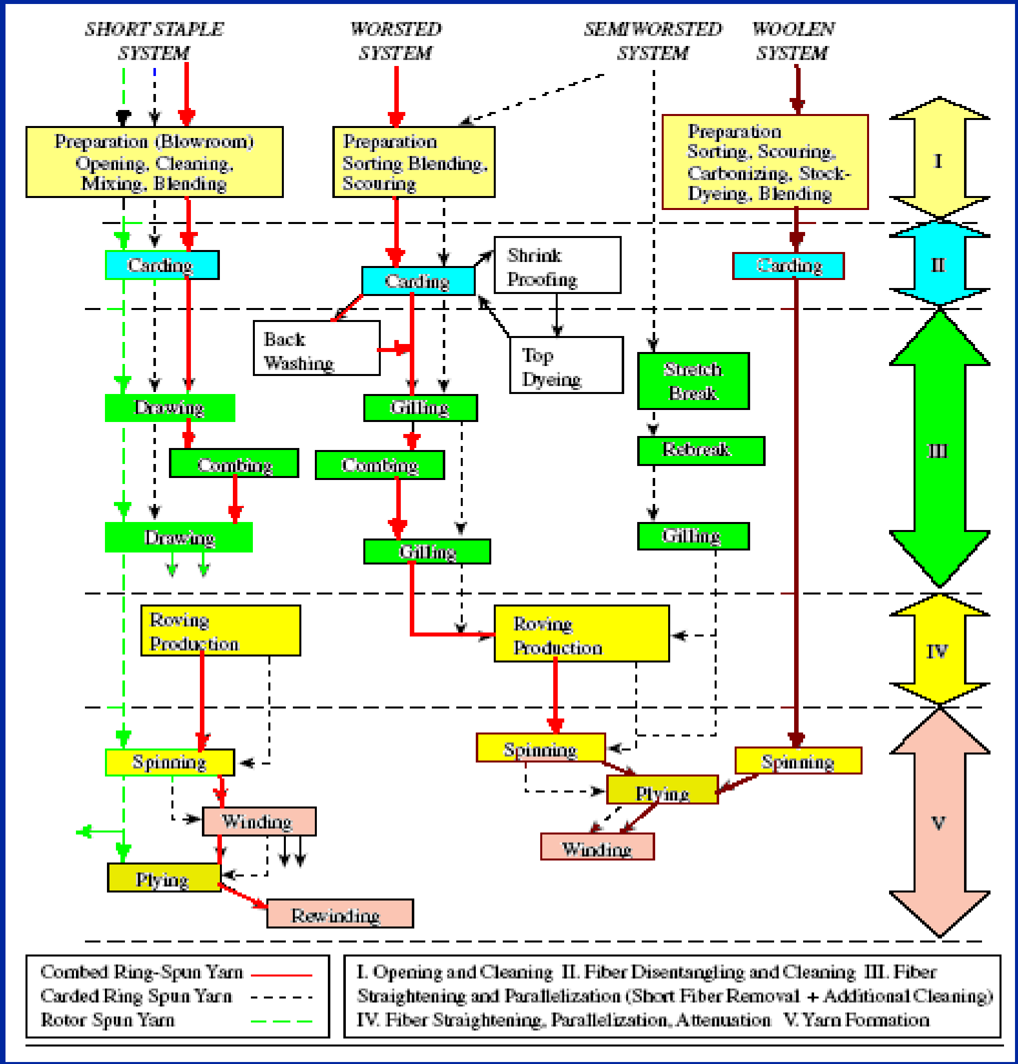
Yarn diameter is given as the value of 50% blackness function. Yarn hairiness is given as the integral under the hairiness curve in the interval of (d/2; 3*d).



Evaluation of yarn diameter and hairiness

Yarn forming systems I

the fibers must be already straight and parallel in the fiber assembly presented for consolidation by twist or some other means. The first stage in a yarn production process is therefore the cleaning and disentangling of the raw material. Where grease has to be removed, the material is scoured. The disentangling of the fiber mass occurs progressively using pin or saw-tooth wire-covered rollers. The earlier stages are collectively referred to as opening and cleaning. The final stage of disentanglement is called *carding,* where the fiber mass is separated into individual fibers that are collected together to form a twist-less rope termed *card sliver.* . To straighten hooked and folded fibers, and greatly improve fiber alignment along the sliver axis, the sliver is thinned by stretching; the mechanical action is called *drafting,* and the amount by which it is stretched is the *draft.* it is sometimes necessary, after the first passage of drawing, to remove from slivers some fibers that are much shorter than the mean length of the distribution.



Yarn forming systems II

The process for doing so is known as *combing*, and, as the name implies, a pin surface is used to comb through the fiber mass of first-passage drawn slivers, removing fibers of pre-selected short lengths. The most common approach is to attenuate the sliver into a roving and then to attenuate the roving during spinning prior to twist insertion, or other means, to form the yarn structure. Roving production is then the last of the preparatory stages to spinning.

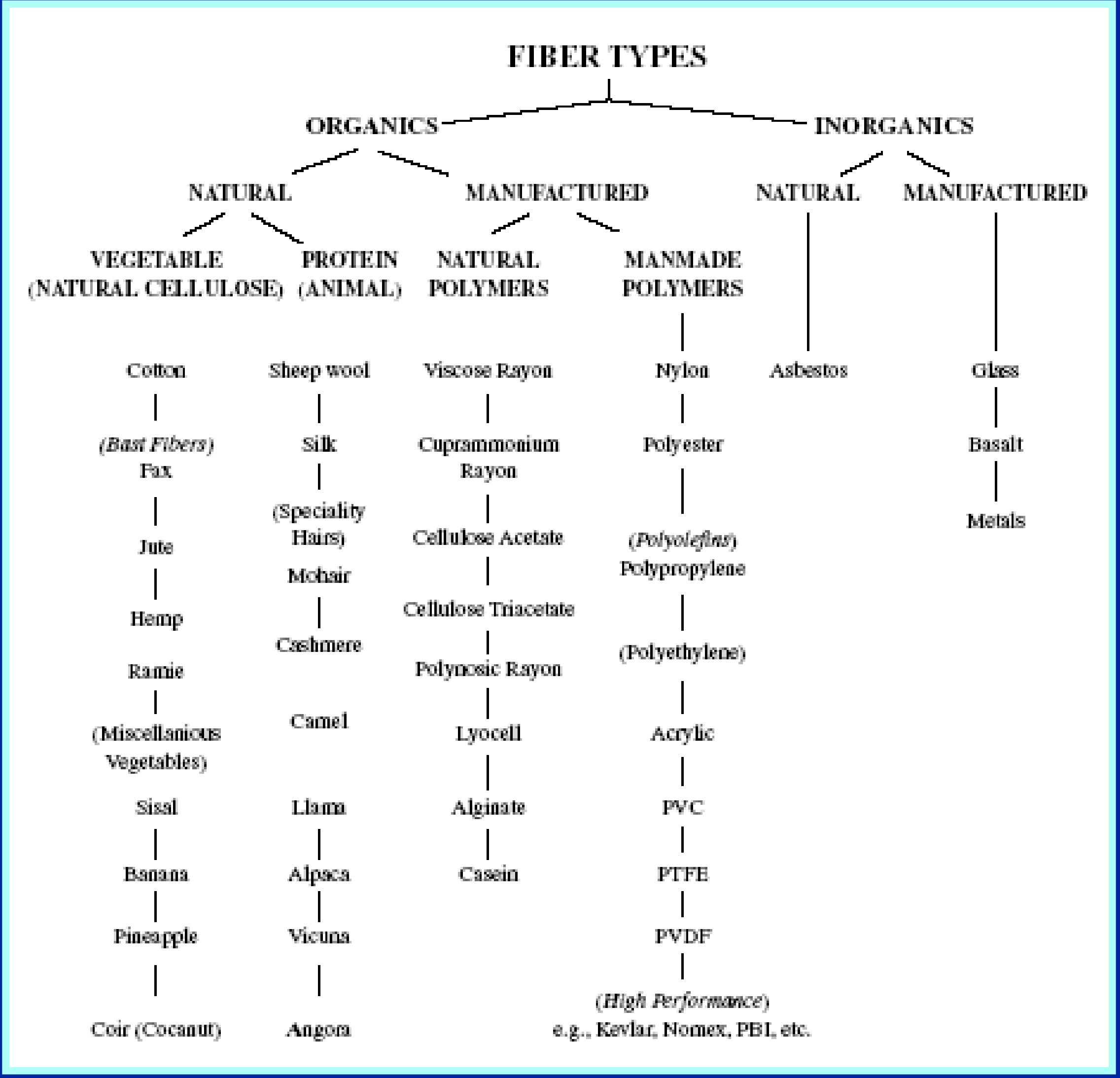
Yarn forming is achieved by further attenuation of the roving through a draft system built in the spinning frame and twist is inserted for consolations of the fiber and a suitable winding system is required for form the yarn.

Following the ring spinning and any plying processes, yarns are usually rewound into large-size packages; these usually take the form of a parallel-sided cheese shape or a cone shape, suitable for use in fabric production and the process of producing such packages is known as winding. Winding is important, because it provides the opportunity for removing imperfections (faults) from the yarn and thereby assists the efficiency of the subsequent processes and improve fabric quality. Yarns can also be waxed during winding to improve knitting efficiency. The point of importance, however, is that a rewound package is along continuous length of yarn, which enables a long running time of fabric production.

Principle of different yarn forming processes will be explained later and its effect on yarn characteristics.

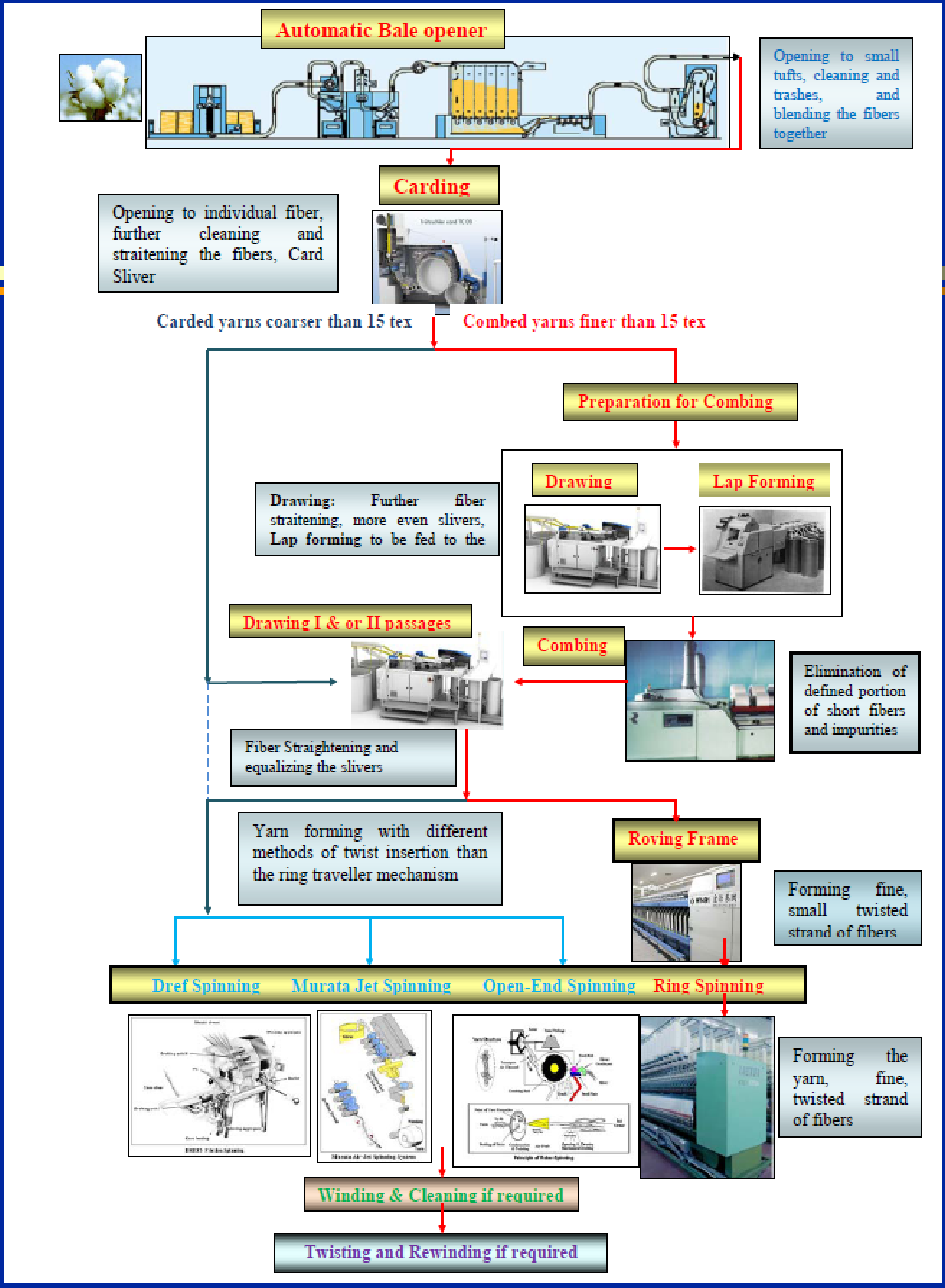
Fiber types

Approximately 90% of world fiber consumption is processed into yarns, 7% into nonwovens, and the remainder used for fillings, cigarette filters, etc. Since circa the 1960s, there has been a general growth in world population and an increase in disposable income in the developed economies. As a result, consumer demand for easy-care, comfortable fabrics has led to manufactured fibers, largely synthetics, assuming a significantly increased share of world fiber production, accounting for 57% of production, while natural fibers have declined to 43%. Of the synthetic fibers, polyester accounts for the largest tonnage (59.3%), followed by the polyolefins {polypropylene + polyethylene} (18.4%), polyaimde (13.1%), and acrylic (8.5%). Cotton accounts for around 33% of total fiber production. Wool has only a 2.3% market share.



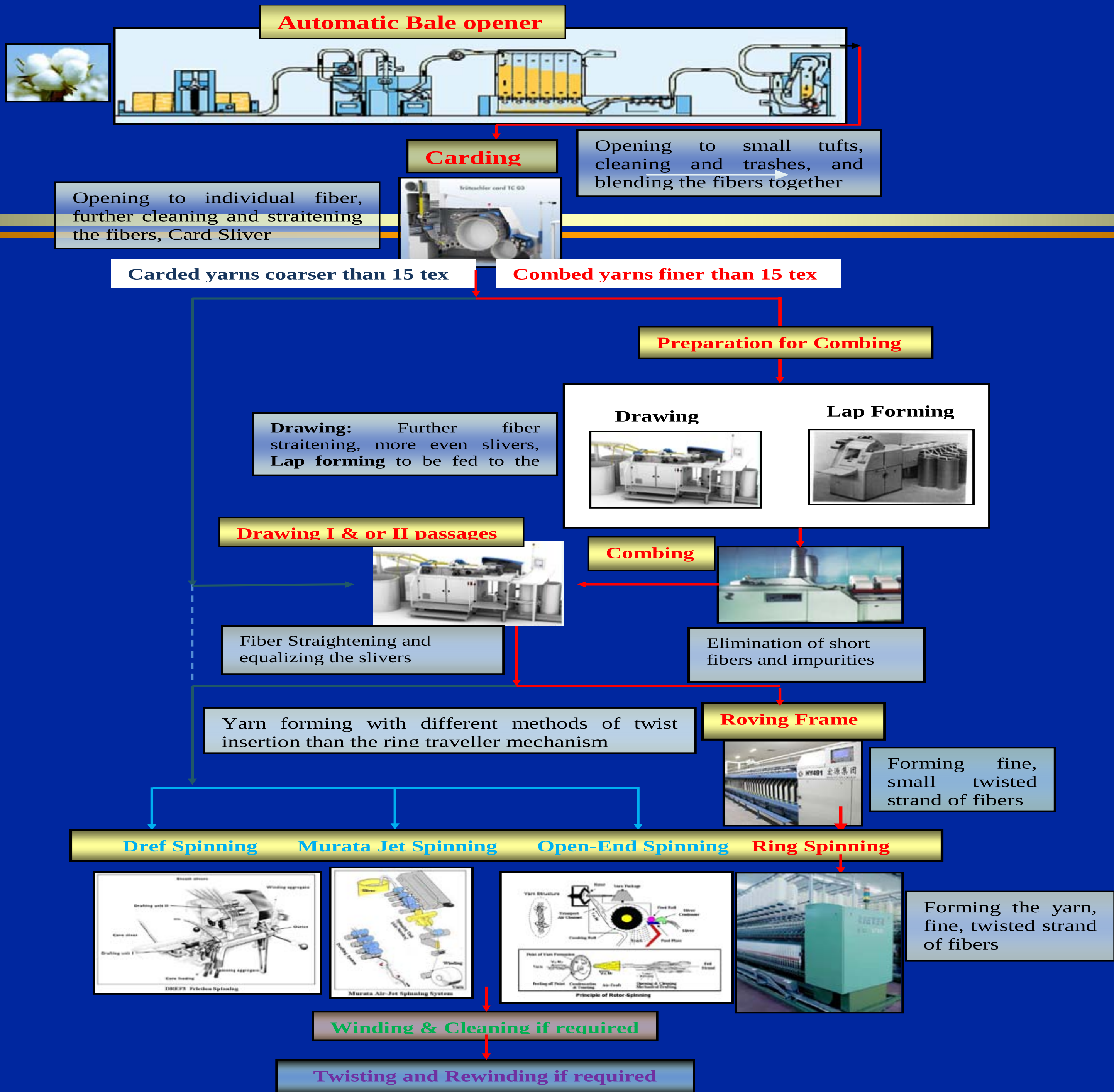
Cotton Yarn Production

When cotton and short-staple man-made fibers (MMFs) are delivered to a spinning mill, they are usually received in the form of compressed, high density bales of 1.5 m x 0.5 m x 0.5 m in dimensions, weighing 230–250 kg, and of 613 kg m^{-3} density. A typical production rate for, say, a medium size mill would be of the order of 500 kg h^{-1}. This means that the equivalent of one bale of fiber would need to be processed every 1/2 hour. Depending on the fineness, length and density of the fiber type to be converted to yarn, the bale can comprise 1.5 to 50 x 10^9 fibers (50 billion); this calculates to approximately 30 million fibers per second removed from the baled stock. The most practical way of doing this is to remove clumps or tufts of fibers from the bale and then progressively reduce the size of these tufts into smaller tufts or tuftlets ultimately reaching the state of a collection of individual fibers which can be subsequently spun to make the required yarn.

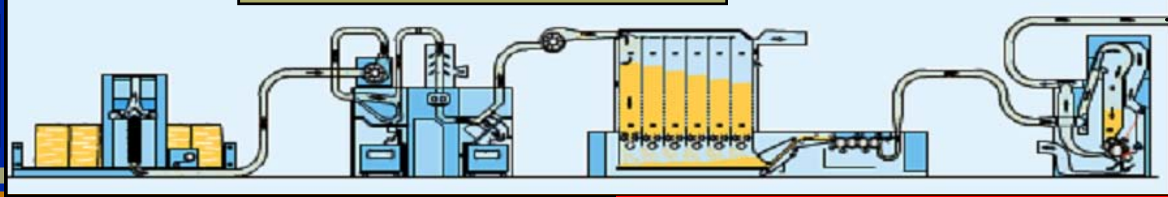


Sequence of Cotton Yarn Production

The baled fiber mass is to be opened into small tufts, a sequence of machines is used to perform this task and to carry out cleaning of the tufts. The machine sequence is called an opening and cleaning line. This is achieved by airflow through pipe ducting linking the machines and is described as pneumatic transport. The tufts are effectively blown from one machine to the next in line, hence the term "the blowroom" is originated. Once the fiber mass is suitably opened, cleaned and blended it arrives at the carding machine and here the tufts are discredited into individual fibers which are reassembled into the form of a twist-less rope of disentangled fibers, i.e. a linear mass of fibers held together largely by inter fiber friction, This is known as "Card Sliver". The fibers in the carding sliver needs to be better straightened and paralyzed and to be more even, this task takes place on the drawing frame; the output is known as "Drawing Sliver". Depending on the quality of the yarn, Preparing for combing and combing are set in the production line. In the combing Process, a precise percentage of short fibers are removed, beside getting red from the impurities as dust, seed coat particles and leafs. The output of this stage is known as "Combed Sliver". The combed sliver passes through two passages of drawing frames, to equalize the slivers through the doubling. This is necessary for producing quality yarns. Because of the limitation of the draft on the Ring Spinning frame, a Roving frame is set in the line to produce the roving. The roving is more finer than the sliver through the drafting system of the roving frame. The roving has low protective twist to facilitate winding on a bobbin . The Roving is fed to Ring spinning frame where the fibers are drafted, consolidated by twist due the Ring-traveller system. Other principles are used for yarn production such as Open-end, Air Jet and Dref Spinning systems, and many other systems.


Automatic Bale opener
Carding
Opening to small tufts, cleaning and trashes, and blending the fibers together
Opening to individual fiber, further cleaning and straitening the fibers, Card Sliver
Carded yarns coarser than 15 tex
Combed yarns finer than 15 tex
Preparation for Combing
Drawing
Lap Forming
Drawing: Further fiber straitening, more even slivers, Lap forming to be fed to the
Drawing I & or II passages
Combing
Fiber Straightening and equalizing the slivers
Elimination of short fibers and impurities
Roving Frame
Yarn forming with different methods of twist insertion than the ring traveller mechanism
Forming fine, small twisted strand of fibers
Dref Spinning
Murata Jet Spinning
Open-End Spinning
Ring Spinning
Forming the yarn, fine, twisted strand of fibers
Winding & Cleaning if required
Twisting and Rewinding if required

Automatic Bale opener



Opening to small tufts, cleaning and trashes, and blending the fibers together

Carding

Opening to individual fiber, further cleaning and straitening the fibers, Card Sliver

Carded yarns coarser than 15 tex

Combed yarns finer than 15 tex

Preparation for Combing

Drawing

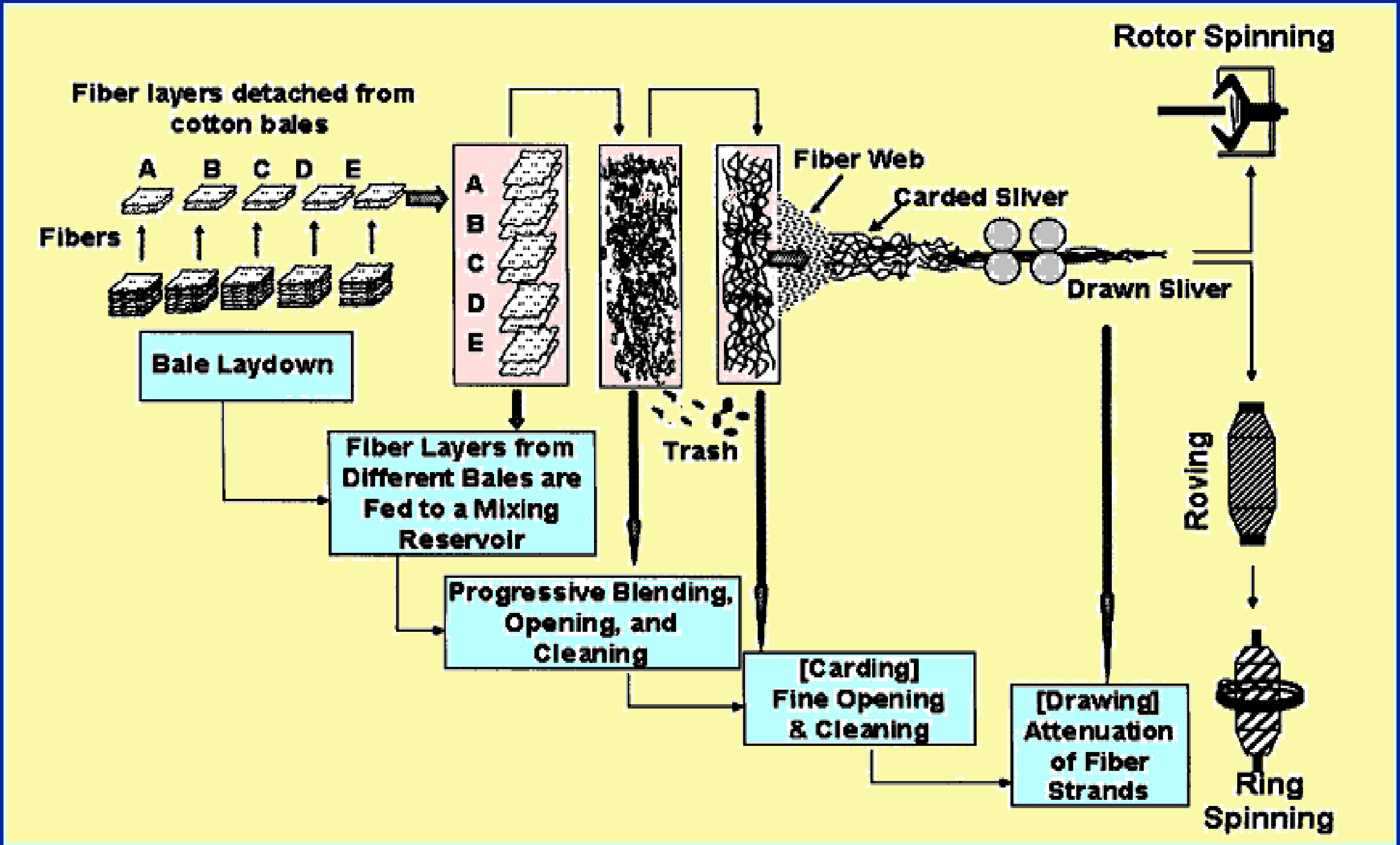
Lap Forming

Combing

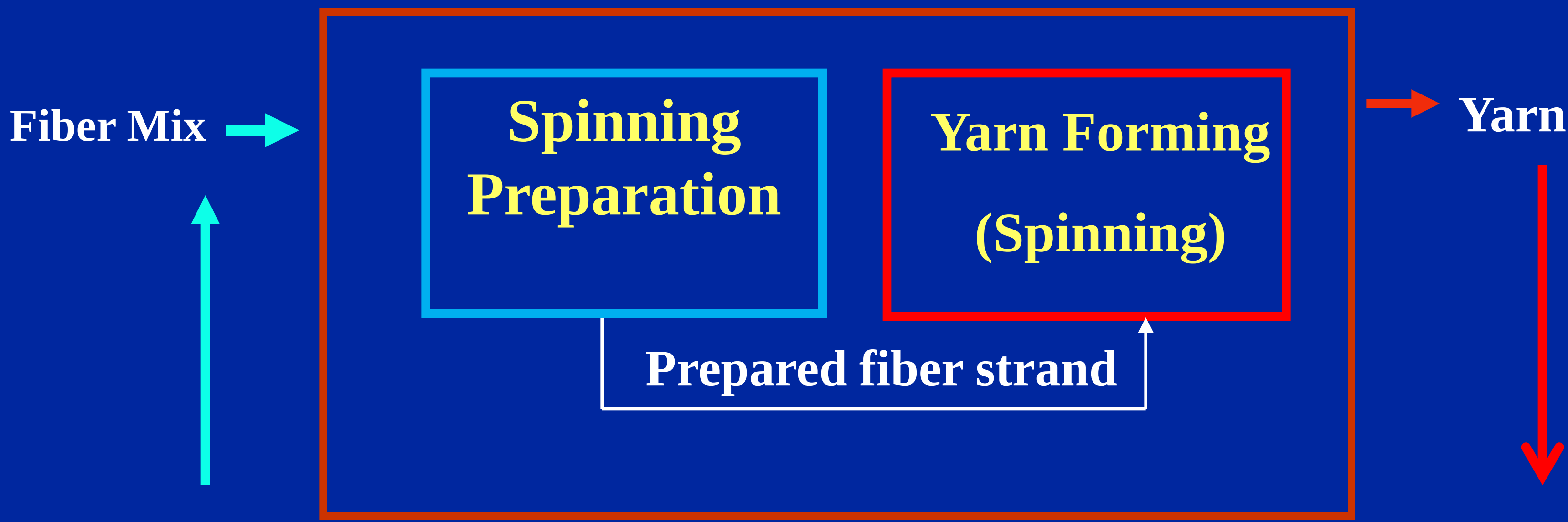
Drawing I & or II passages

Principle of Fiber to yarn conversion systems

•Convert a high variable raw material to a very consistent fiber strand.
•Variability exists Within bales, Between bales within one mix, and Between mixes (lay downs).
•Quality criteria is high degree of uniformity, consistent properties along the yarn.
•fibers are normally intermingled with all kinds of trash, dust, seed coat fragments,…
•The yarn produced must be pure, clean and defect free and



Tasks of the fiber to yarn conversion system



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

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

Opening, Cleaning and Fiber Mixing

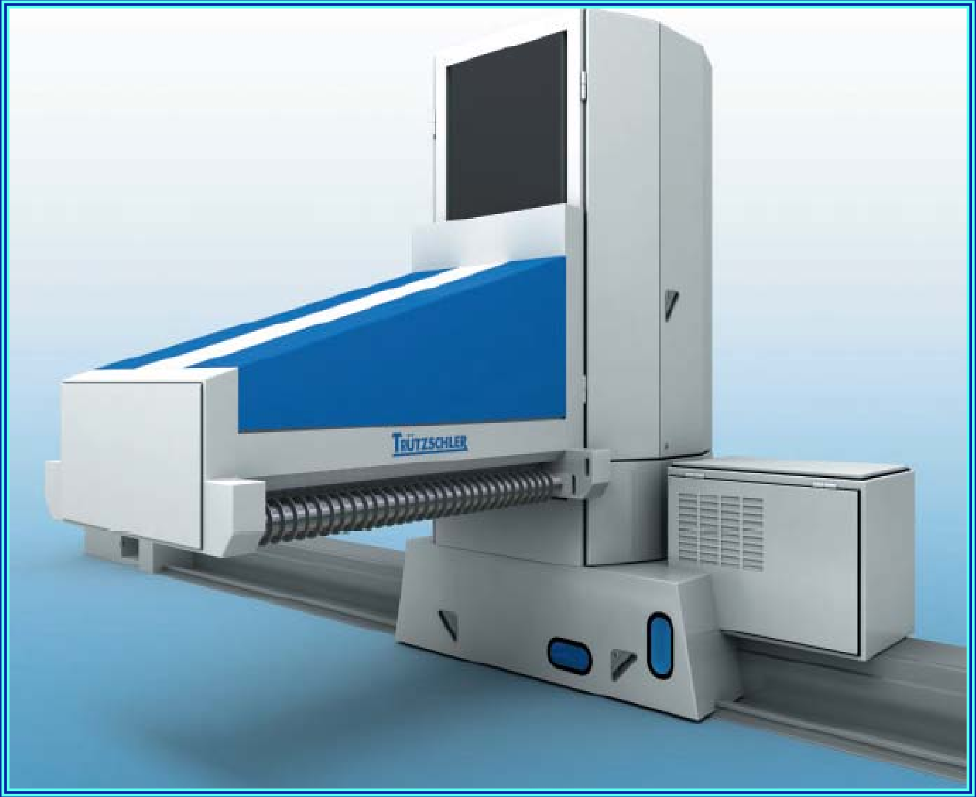
Short Staple Pr-Spinning Machinery

Short Staple Pr-Spinning Machinery

•*All Modern Spinning mills are equipped by some sort of Automatic Bale Opener.*
•*In General short lines, does not need material handling, and hence less reliable for faults.*

•Short staple pre-spinning *emphasized compact lines with integrated multi-functional equipment.*

•**Major emphases were placed upon equipment allowing for a compact *800 Kg/hr opening line*, an integrated separator, a more precise removal of foreign fibers, and a waste control measuring system.**



Blendomat BO-A, from Trutzschler

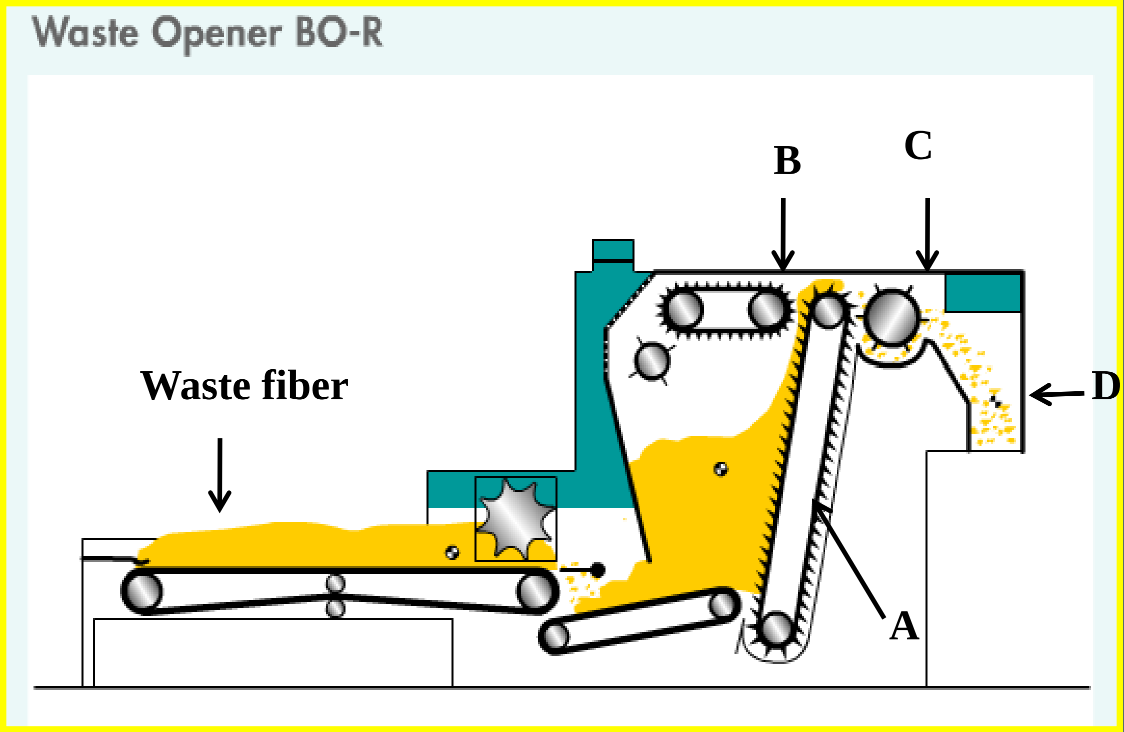
Stage 2 heavy particle detection and extraction

Waste fiber feeder

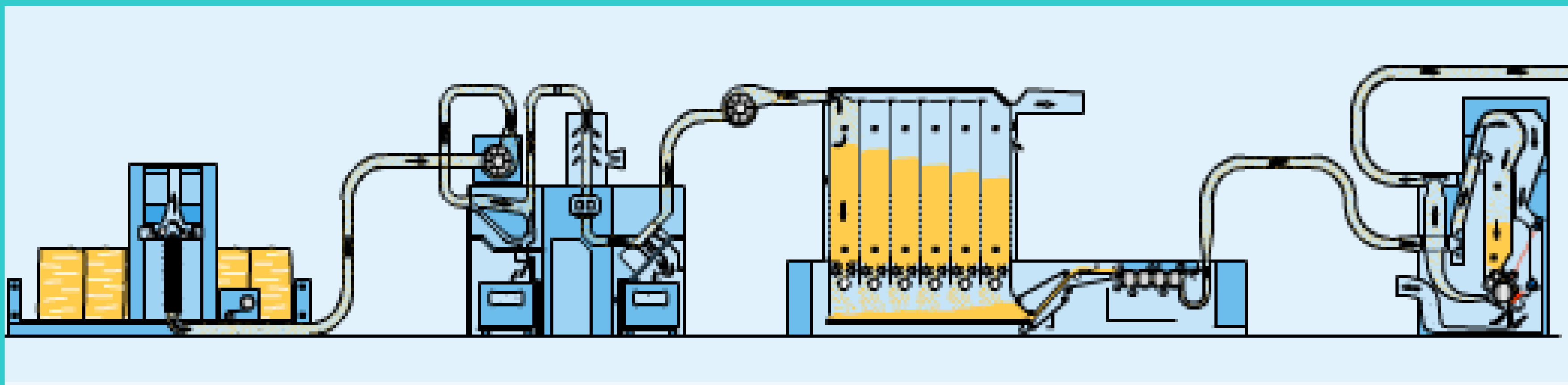
Waste Opener:

Process waste with high fiber content (usually from the intermediate process to spinning, up-stream of the blowroom) may be recycled by feeding into the process line around 5% of waste with the virgin fiber. A waste feeder is illustrated. Here the fibrous waste is fed from the hopper by the inclined spike lattice (A) and evener belt (B) to return back the big clubs to the reservoir. The fast rotating spike roller (C) which separates the fiber mass into tufts. The opened fibers (D) can be directly fed to the automatic bale opener for further processing.

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.



Modular Opening Line Component

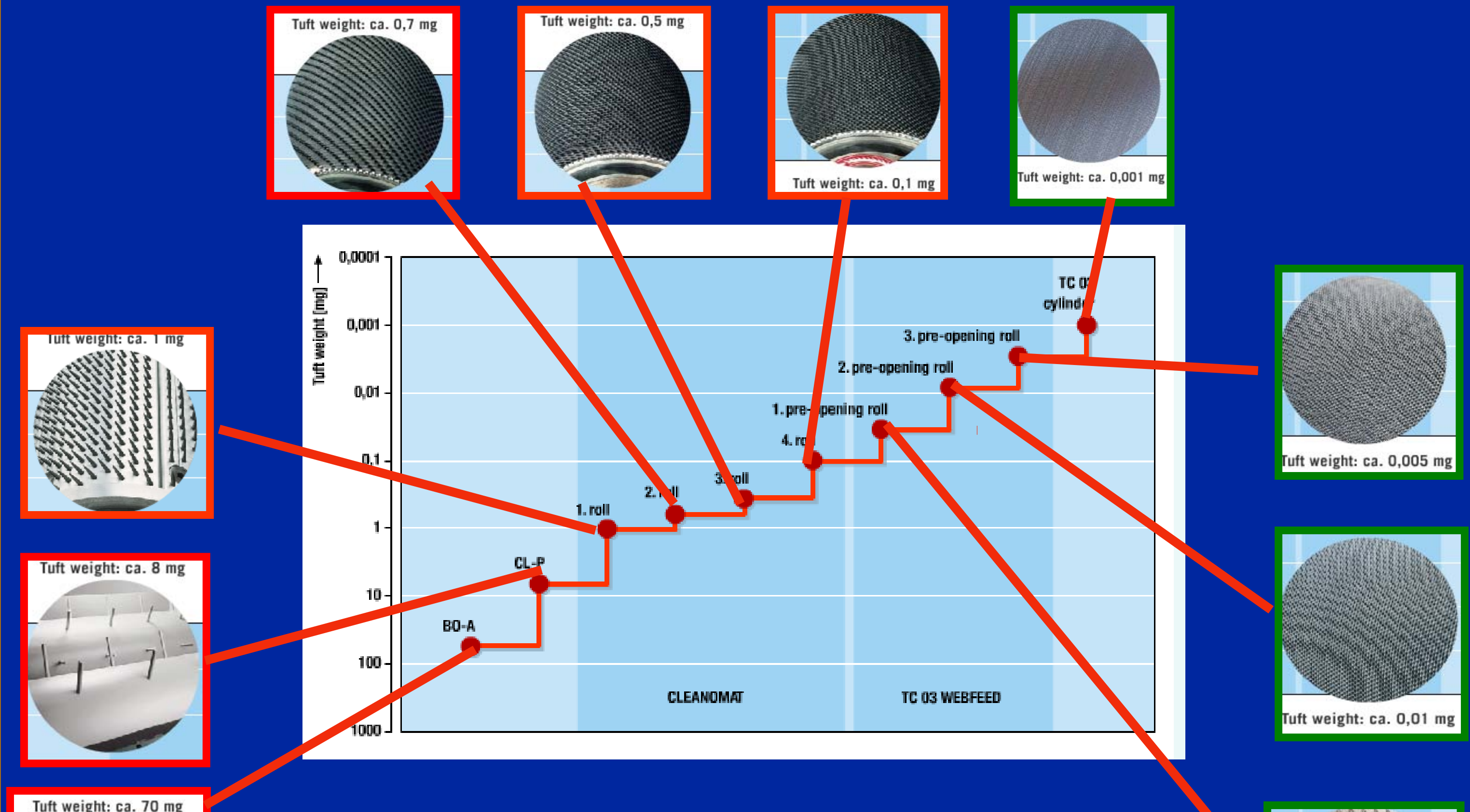


Automatic Bale Opener BLENDOMAT BO-A	Multi Function Separator SP-MF	Integrated Mixer MX-I 6 and CLEANOMAT Cleaner CL-C 4	Foreign Part Separator SP-F

- The Different machines comprising the opining line are multi functional
- 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

Principle of Opening

All opening or the beating elements of the different machine in the opening line, should work in harmony. At the beginning elements are robust with low attack angles, running at low speed, while at the end, elements are fine, with sharp angles, running at high speed. This is to insure gentle and efficient opening action. The big and heavy impurities are easier to separate than small and light particles. Beating in free state is more gentle than beating in clamped sate.



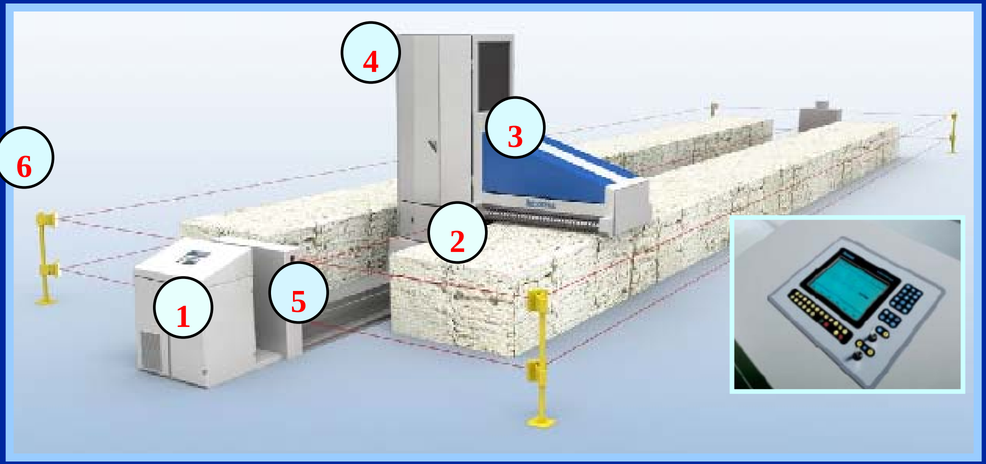
Gradual and Gentle Opening

Stage 1: pre-opening/pre-mixing

Main Features of Blendomat BO-A

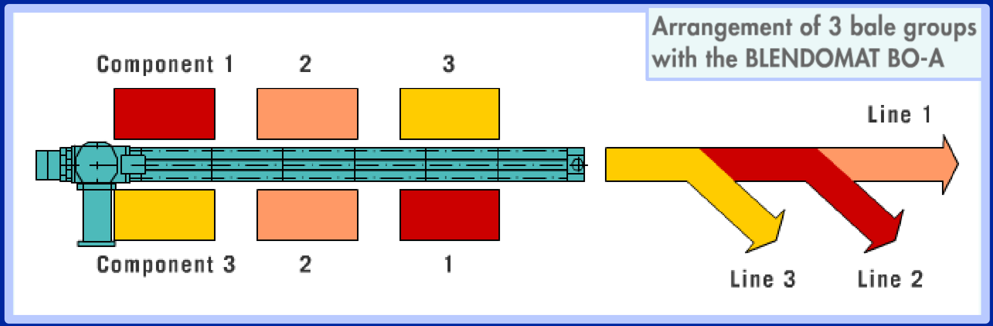
Diagram of automatic bale opener:

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



One- or two-sided operation with no loss of flexibility. During the change-over phase from one set of bales to another, it is possible to continue processing both of them.

A specially developed light barrier system over the suction duct enables positioning of the bales while production is running without any risk for the operator.



Automatically adapts its traversing speed to the production requirements.

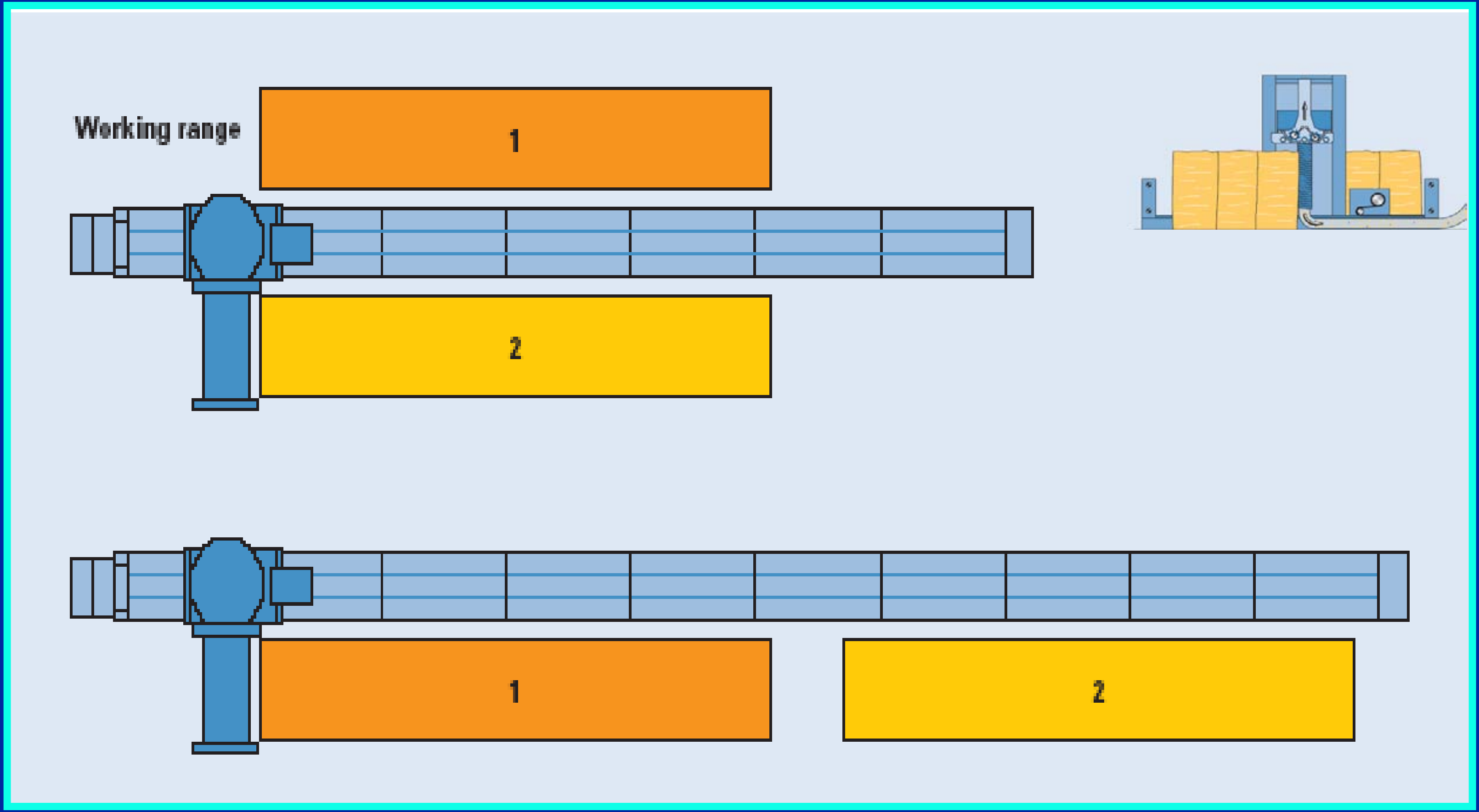
A frequency controlled drive motor allows traversing speeds between 6 and 13 m/min, adopted to the respective production requirements.

The production rate is up to 1,500 kg/h.

Double light barrier, Machine control, and visualization of process

Alternative Layout of Bales

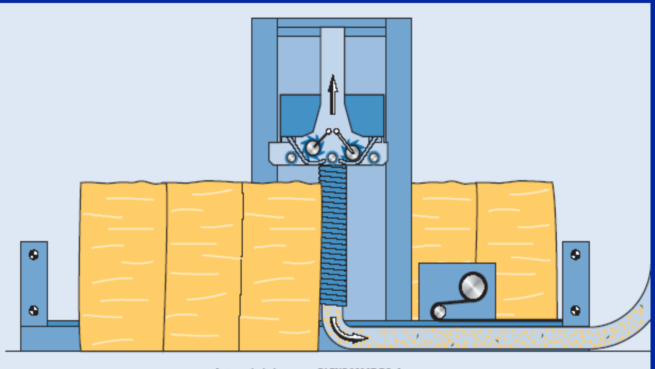
In small room, it is possible to arrange the working areas next to each other



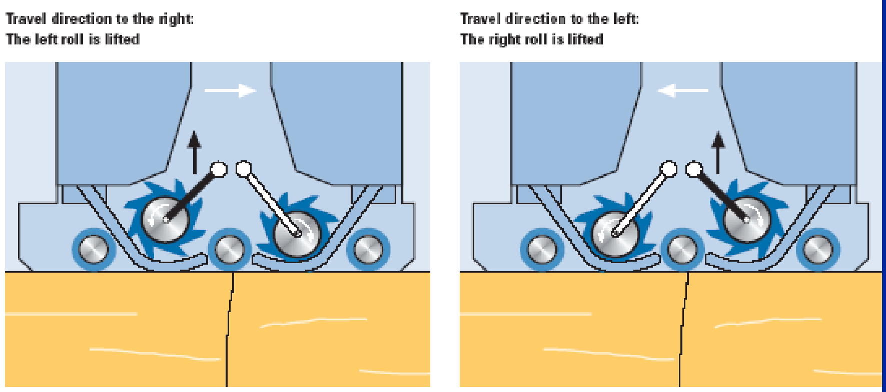
Working Principle of Automatic Bale Opener BO-A

The figure illustrates the situation for two opening rollers traversing the bale laydown. Whatever the traverse direction, one roller will always have its working toothed discs opposing the traverse, while the other will be with the direction. For production rates from 400 to 1400 kg/h, tuft sizes fall with the range of 30 to 80 mg and, depending on machine type, bales can be processed at an incline so as to facilitate better tuft blending. Bale lay-downs can be up to 180 bales and, as the working head tower can be made to automatically swivel, bales can be assembled on both sides of the traversed path. This facility can enable early stage blending of tufts of, for example, a three-component blend as illustrated in figure.

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



Automatic bale opener BLENDOMAT BO-A



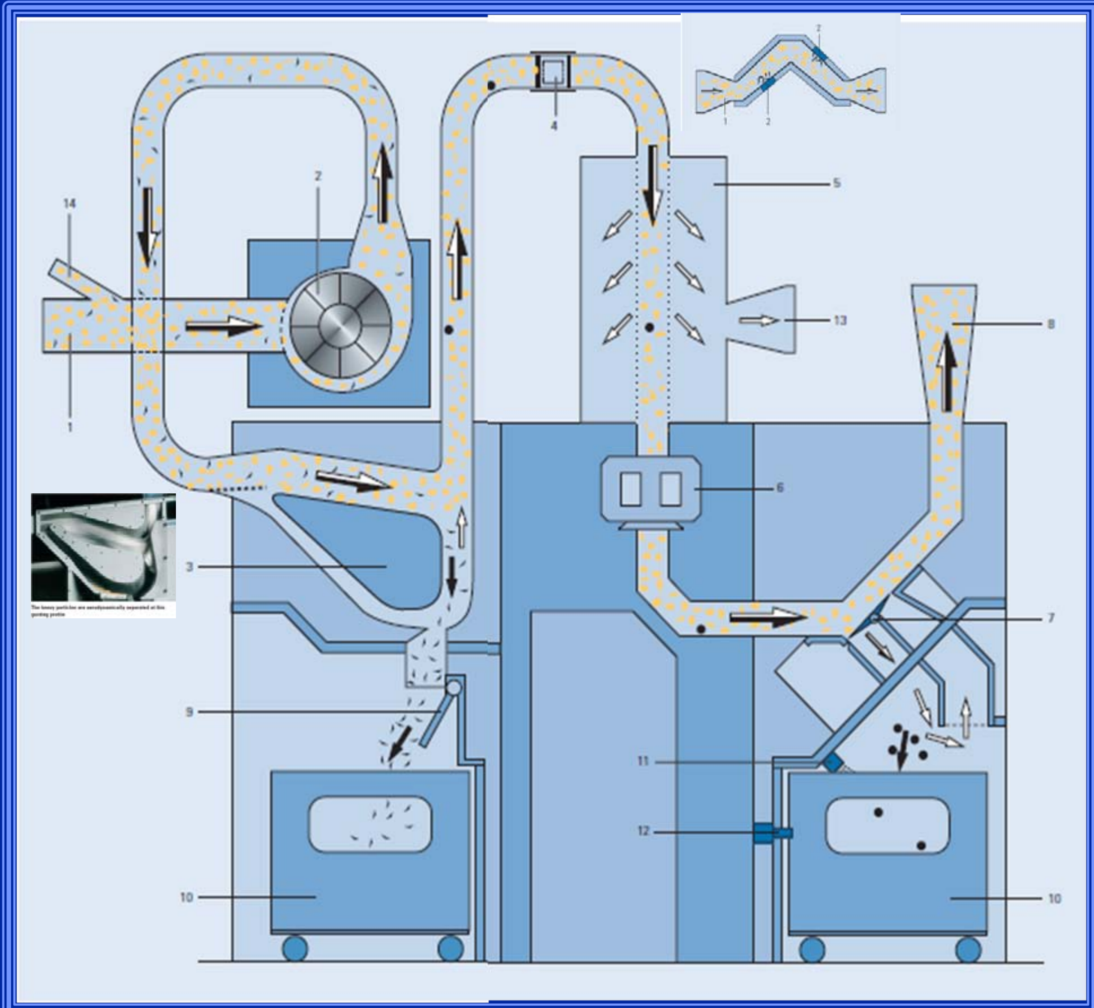
The penetration control mechanism of the opening roll guarantees always equal tuft sizes and an even distribution of production between the rolls

With a working width of 1720 mm and a machine length of 50 m, about 130 bales can be accommodated. The BLENDOMAT with a working width of 2300 mm even accommodates up to 180 bales. Assuming a cleaning line production rate of 800 kg/h, this allows unattended operation for two days (48 h).

Stage 2 heavy particle detection and extraction

Multi-Function Separator SP-Mf

1 The material is sucked off an automatic bale opener BLENDOMAT BO-A.
2 The fan is automatically controlled to guarantee a constant negative pressure
3 A new guiding profile has been developed 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 The metal detector detects any kind of metals
7 The diverter does not work with pre-tensioned springs, but is actively opened and closed
8 The next machine, normally a fan in front of the mixer, sucks the material off here.
9 A flap feeds the separated heavy particles into the waste container with castors
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 is fed to a filter installation
14 Opened waste from the waste opener BO-R can be added without additional fan



The tufts are of a lower density than the heavy foreign particles, and fibers forming the tufts also have a greater surface area to weigh ratio. The airflow transporting the material through the machine can be used to effect removal of the impurities.

Stage 2 pre-cleaning

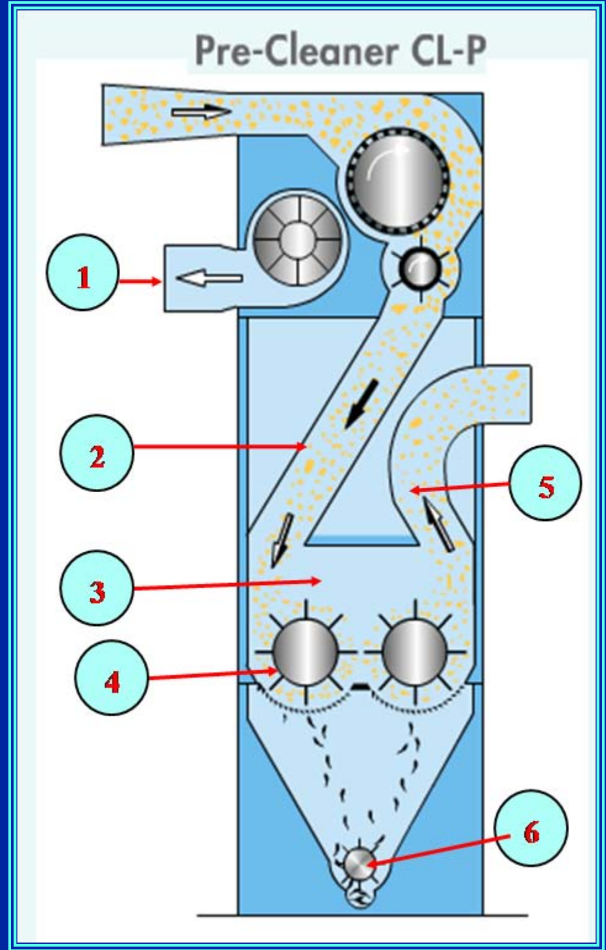
The opener/pre-cleaner is comprised of a wire-mesh cylindrical drum, termed a condenser (1), a feed trunk (2), a cleaning compartment (3), beaters and grid bars (4), an exit suction trunking (5) and a waste removal device (6). The arrows indicate the flow of the tufts.

The condenser fulfils two functions. It removes dust particles in the air stream and from the surface of the tufts as they are 'condensed' onto it. Second, its rotation transports the tufts into the feed trunk, which is positioned to ensure tangential feeding to the left beater or cleaning roll. The two beaters are basically cylindrical rolls with metal rods projecting from the roller surface.

When the fiber mass of a large tuft is opened into smaller tufts (approx. 8 mg) by the beaters, fibers in one part of the mass will slide past fibers in another part. The interfibre friction will liberate dust particles attached to fiber surfaces and importantly will move trash particles to the surface of the smaller tufts.

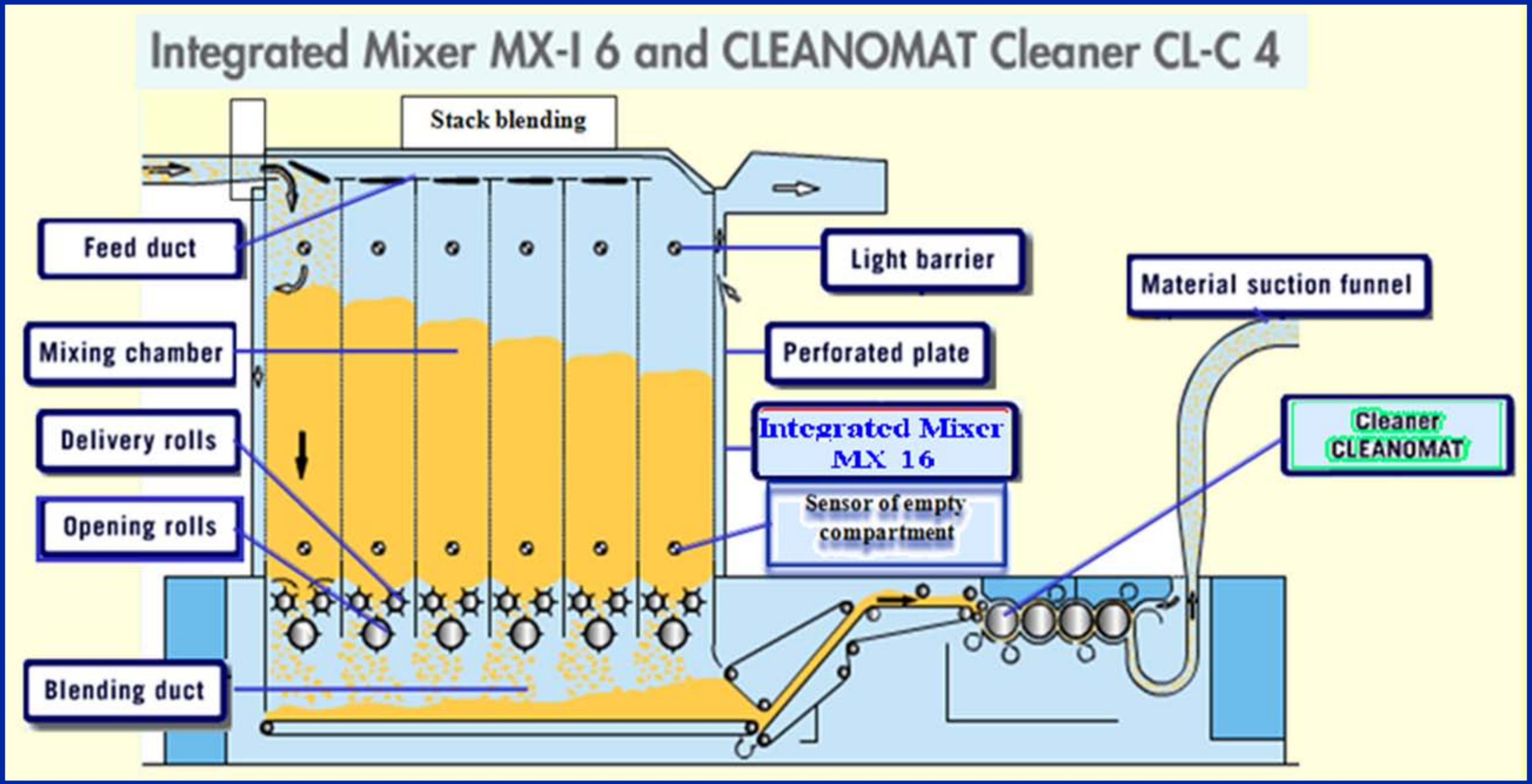
The two cleaning rolls with a new arrangement of the spikes

These particles cling to the surface fibers and to remove them, the tufts are thrown against (and pulled over) narrowly spaced bars (grid bars) so that the impact shakes the particles from the tufts and ejects them 6 through the gaps of the grid bars. This 'beater and grid bars' technique is a commonly employed pre-cleaning action.



Stage 2: Blending/mixing

Integrated mixer



The direct feeding of a cleaner of the CLEANOMATsystem by an integrated mixer MX-I is an important element of the compact blowroom. This mixer produces a homogeneous and even web for feeding the cleaner. The air separation at the mixer provides additional dust removal. This combination of a cleaner with a mixer is the solution which ensures the greatest savings in floor space and energy and is the preferred solution when processing cotton.

Basics Blending/mixing

The operation of a stack blender is depicted in the figure. The basic principle of stack blending is to fill, sequentially, a series of vertical compartments in a storage bin (providing stacks of tufts), and then to remove layers from consecutive stacks in a manner that sandwiches the layers, thereby dispersing and mixing tufts, say, from the first traverse of the bale lay down with tufts from subsequent traverses. The figure shows a stack blender of six vertical bins, referred to as a six fold mixer; a four fold mixer would comprise four vertical bins, and so on up to a ten fold mixer.

As the figure illustrates, whilst fiber tufts are being deposited into the bins, previously accumulated tufts are dropped simultaneously onto a moving belt. With the movement of the belt towards the exit of the blender, the drops from the first bin forms the first layer that receives the deposits from the second bin, which forms the second layer, and this in turn receives the third deposited layer from the third bin. This sequences of deposition eventually forms a sixth layer accumulation that is continuously fed to an intensive opener and cleaner (the four-roller cleaner). The top left of Fig. 7.8 illustrates that significant benefits may be obtained with consecutive stack blending. There are three important reasons for blending.

1. *Reduction of the production cost. Production cost = raw material cost* + conversion cost, the latter accounting for capital, labour, space, maintenance, etc. The raw material element can account for around 50% of the production cost.

2. *Product development. Often this aspect involves blending cotton with* man-made fibers, such as cotton/polyester blends for easy care fabrics, acrylic/cotton blends for increased bulk and handle in, say, sportswear.

3. *Improvement in processing performance and/or upgrading yarn quality.* Often when lower grade cottons are being processed good blending can be critical to the downstream process efficiency and the resultant yarn quality, in terms of irregularity, strength and hairiness.

Estimation of Blend Properties

The proportions of each constituent of a fiber blend can be estimated from:

$$W_b = w_1 + w_2 + w_3 + \dots + w_n = \sum_{i=1}^{n} w_i$$

$$p_1 = \frac{w_1}{W_b} \ or \ p_i = \frac{w_i}{W_b}$$

where, W_b is the total mass, w_i and p_i are individual mass contributions and blend fractions of the fiber components

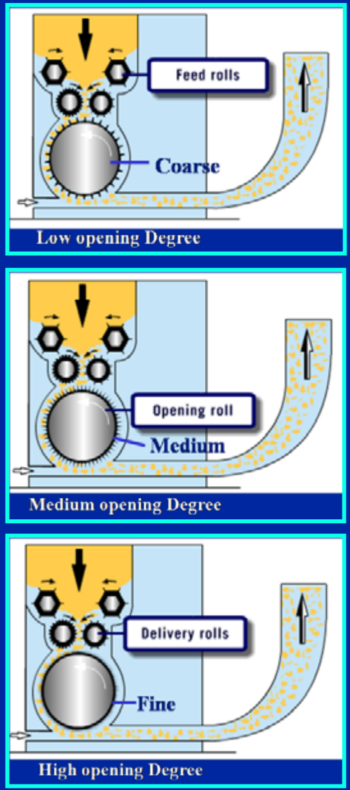
Formulation of fiber blends

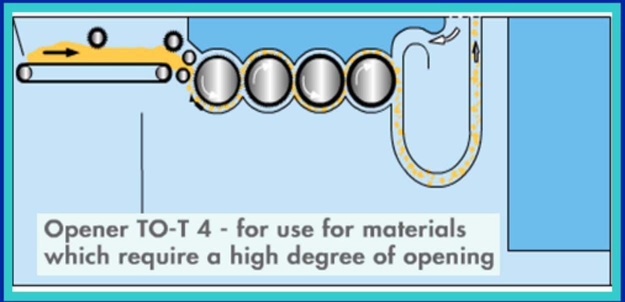
Fiber characteristics	Blend equation
Diameter	$d_m^2 = \sum p_i d_i^2$ where d_m mean of the blend, p_i and d_i the proportion and mean diameter for each blend component for $i = 1 \ to \ n$ components
Count (mtex)	$f_m = 1000/[\sum q_i / f_i]$ where f_m mean of the blend, q_i and f_i the percentage and mean count for each blend component for $i = 1 \ to \ n$ components
Length	$L_m = \sum p_i L_i$ where L_m mean of the blend, p_i and L_i the proportion and mean length for each blend component for $i = 1 \ to \ n$ components
Strength	$S_m = \sum p_i S_i$ where S_m mean of the blend, p_i and S_i the proportion and mean strength for each blend component for $i = 1 \ to \ n$ components

Stage 2: intensive opening and cleaning

Main Features I

The four-roll cleaner employs the intensive opening action of feed roller(s) and beater combination coupled with the cleaning action of beater and mote knife. As depicted in Fig. 7.8 a pair of feed rollers supply the fiber mass of blended tufts to the first of four rolls or beaters covered in sharp points. The arrows indicate the direction of rotation of each beater. The first beater divides the tufts into smaller sizes, freeing trash particles, and transports the mass onwards, the fiber mass reaching the second, third and ultimately the fourth beater. Each successive beater has an increased surface speed and more closely spaced points. Also, each beater is positioned closer to the one it follows. These three factors facilitate effective opening of tufts and freeing of trash particles. Located around the periphery of each beater are deflector plates with mote knives and attached suction hoods for waste particle removal. Each location is referred to as a cleaning point. The deflector plate is positioned close to the beater surface so that as tufts pass by, trash entrained in the flow can be ejected by the action of centrifugal forces near the edge of the mote knives, then deflected by the plate and removed by the continuous air suction The permanent suction results also in the removal of dust particles.





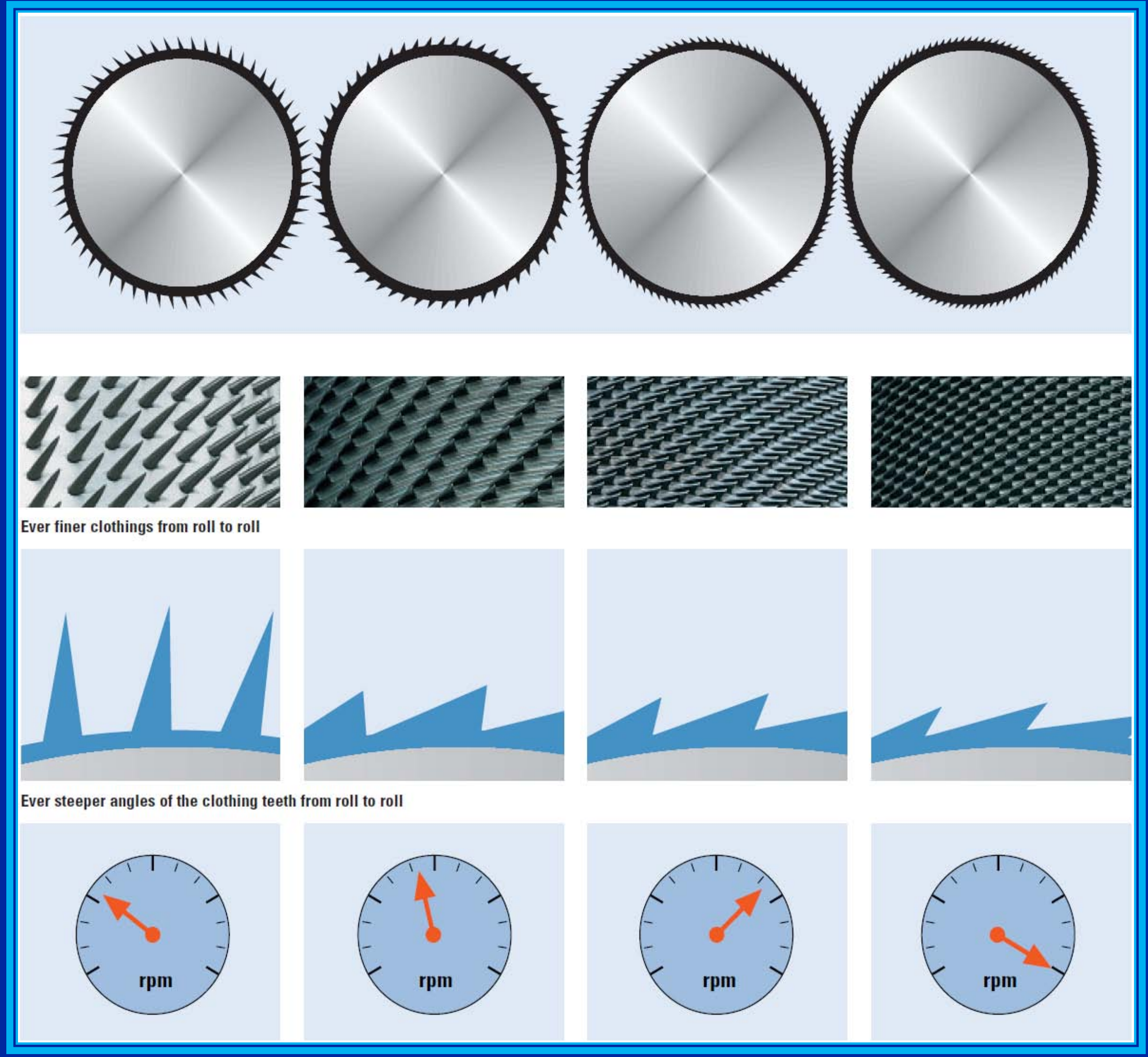
Stage 2: intensive opening and cleaning

Gentle fibre treatment by multi-roll-technology

Finer clothing from roll to roll

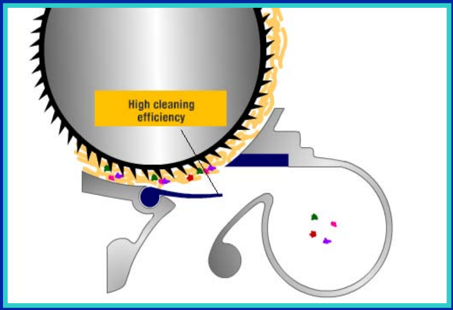
Angles rise from roll to roll

Higher cylinder speed from roll to roll

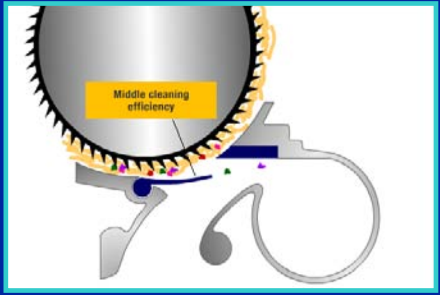


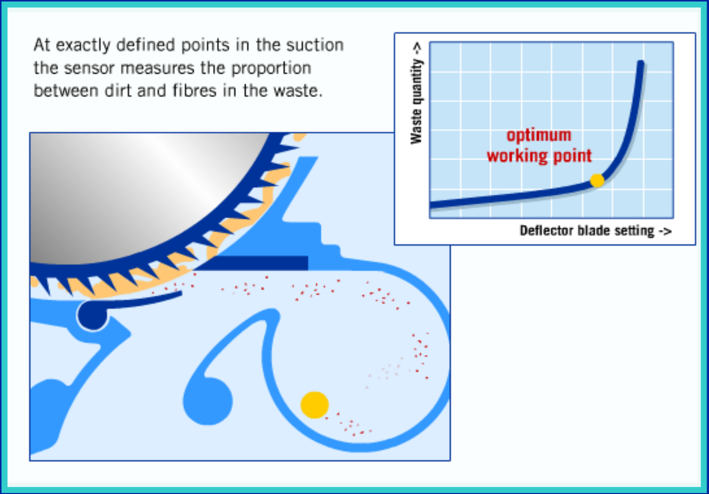
Stage 2: intensive opening and cleaning

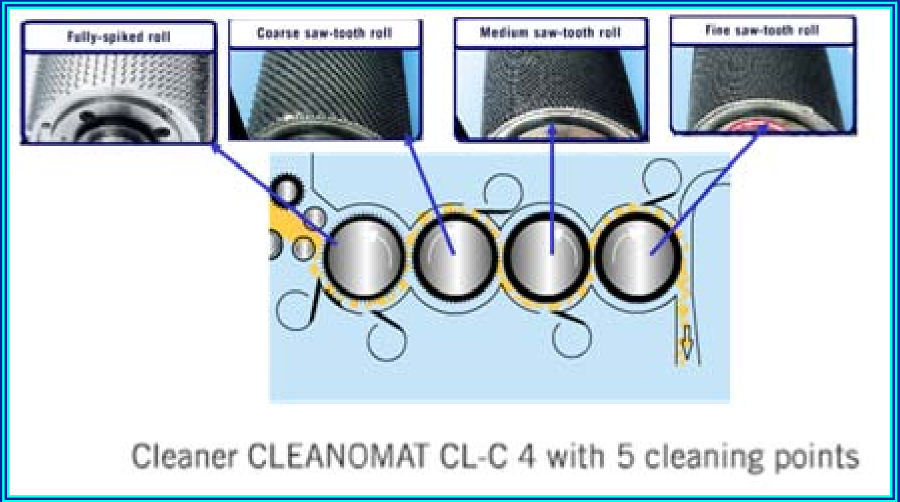
Optimum setting of cleaning



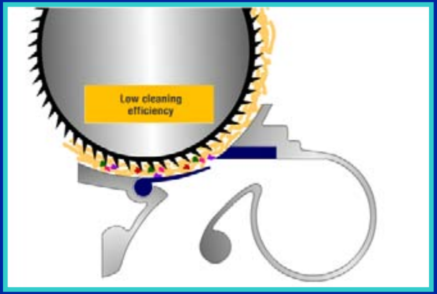
Gentle opening is achieved by having the first beater clothed in pins angled ca. 10∞ from the vertical, and the remaining beaters having saw-tooth clothing, the tooth angle increasing from roller to roller (e.g. 15∞, 30∞, 40∞). The teeth density (number of points per cm2) should also progressively increase 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



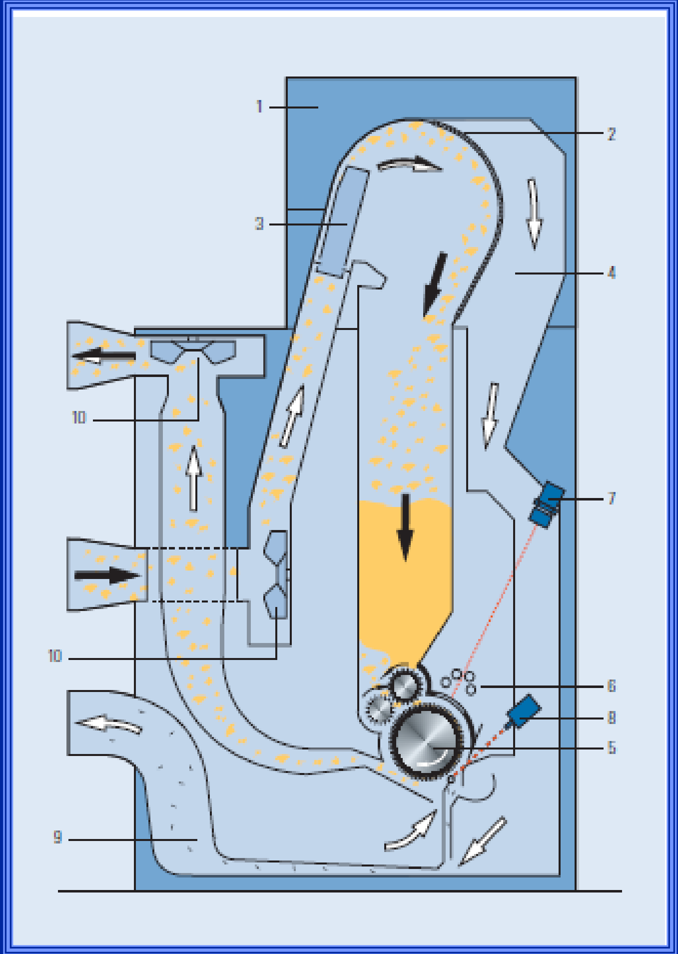
Sensor measures the proportionality between trash and fiber in the waste, and sets the deflection plate at optimum value

Cleanomat CL-C4

Stage 2: intensive opening and cleaning

Foreign Particles Separator

The dedusting section (1) is screened by a large perforated metal sheet (2). Distribution flaps (3) spread the tufts over the surface area of (2) and the dust released is sucked away via (4). The tufts fall into a reserve chute and the mass of material is fed by a pair of saw-tooth rollers to a beater (5) covered in fine pins. The tufts, when caught by the beater, become lightly and uniformly spread over the beater surface. Four fluorescent lamps (6) give high but uniform illumination of the beater surface. Two digital cameras (7) continuously scan the beater surface. On detection of a contaminated part of the fiber mass (F) a bank of compressed air nozzles (8) are selectively activated to blow the contaminated part of the fiber mass from the beater surface into a waste suction unit (9). The fibre mass is therefore screened to be free of material contaminants. The tufts are transported through the machine by airflow generated from two integrated fans (10), and the fan at the exit blows the screened tufts through the trunking to the carding machines of Stage 2.



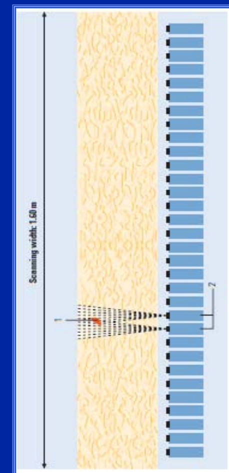
The white arrows indicate the direction of the airflow through the machine, and the black arrows depict the fiber mass flow.

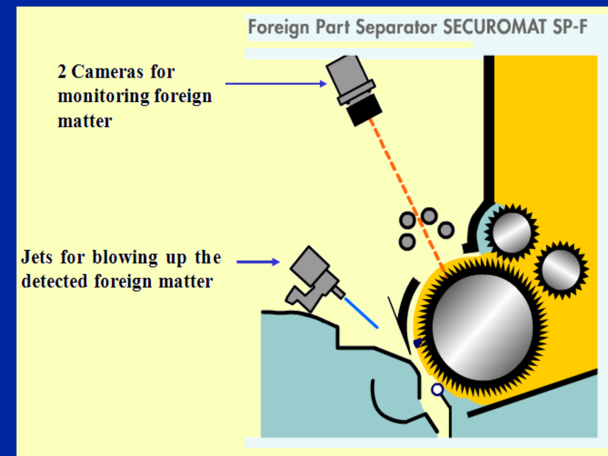
Stage 2: intensive opening and cleaning

Details of Cameras and Separation Nozzles

The final cleaning machine in Stage 2, is the foreign particle separator, indicated as in the figure. Foreign particles often include pigment colored polypropylene bale straps, which get broken down into fine fiber fragments during carding. This results in yarns produced being rejected owing to material contamination. At this part of the blowroom the aim is to significantly reduce the dust still present within the mass flow, but critically also, to detect and remove particle contamination of the fiber mass. The figure illustrates how this is achieved.

Separation of foreign fibers is optically detected. Cotton should be highly opened. This is provided directly before feeding the Material to the card. The SECURMAT SP-F Is used





Control and Visualization System

The electronic installation control LC-I is optimally suited for coordinating the individual machine controls.

• High amount of information in the displays Clear color display

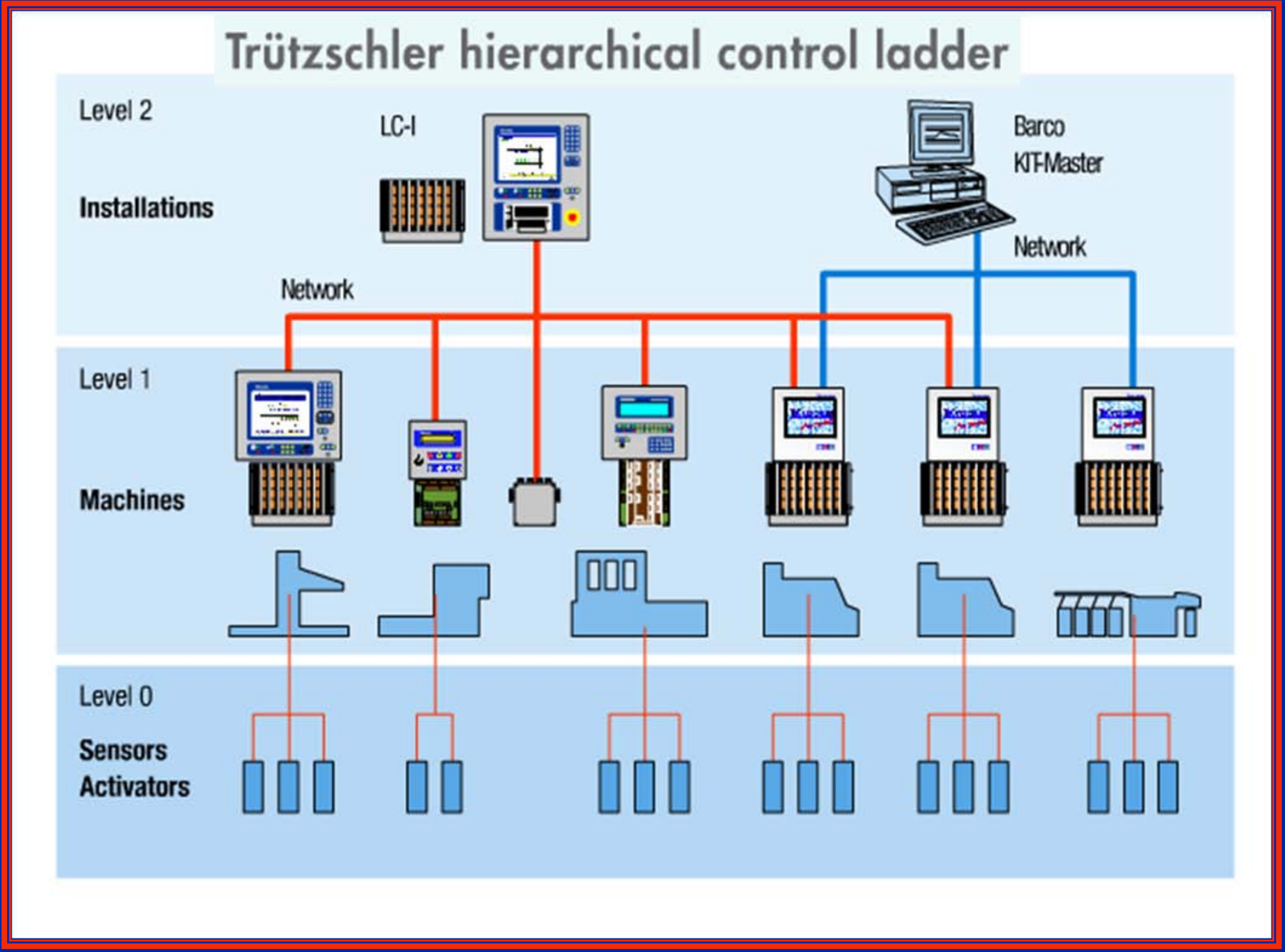
• Low cabling expenditure Same spare parts as for the machine controls

• Simple operation through touch screen High operational reliability

Simple commissioning Using international standards Open system Tele-diagnostics via telecommunication possible

Each machine contain micro-controls All machines communicate with the central unit via network.

The system is of open architecture and offers the possibility to transfer data into the customer's own networks



Optimum Cleaning Efficiency

Continuous material flow for optimum cleaning performance

CONTIFEED controls the material flow between two machines, a cleaning line or opening line as well as between a cleaner/opener and the cards.

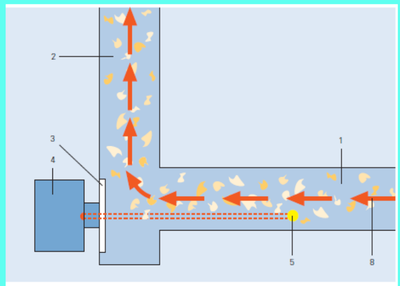
the universal modular control system

Traditional installations operate on a stop-and-go basis, this means the machines are frequently switched on and off because of fluctuations in the production rate. Consistent feeding of the cards improves sliver evenness

The typical application of the CONTIFEED is the control of a cleaner of the CLEANOMAT system. The pressure in the feed duct to the cards serves as a signal to control the material transport motor of the fine cleaner. This results in an exact, continuous feeding of the card tuft feeders.

The evenness of the card slivers is higher than with stop-and-go operation. Only a continuous material flow, adapted to the current requirements, results in a maximum evenness. This advantage has an effect right through to the card sliver.

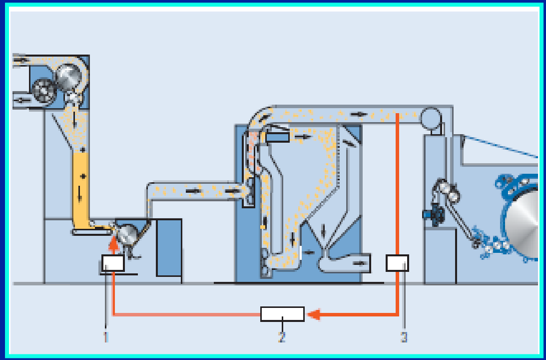
Waste sensor WASTECONTROL BR-WCT The composition of the waste is permanently measured. A waste sensor can be fitted at each cleaning unit of the CLEANOMAT cleaners, which are equipped with a deflector blade.



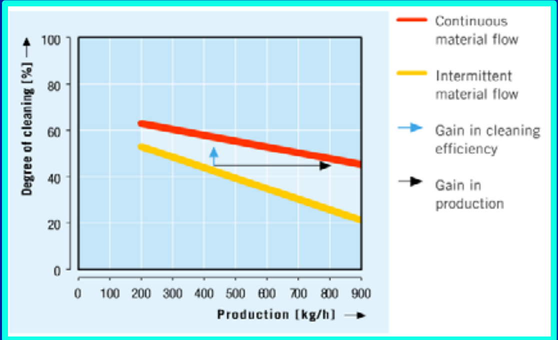
The waste sensor is fitted at the end of the suction hood

1 Suction hood
2 Suction duct
3 Window
4 Sensor
5 Measuring point in the suction hood
6 Cleaning knife
7 Deflector blade
8 Air flow in the suction unit

Continuous material flow for optimum cleaning performance

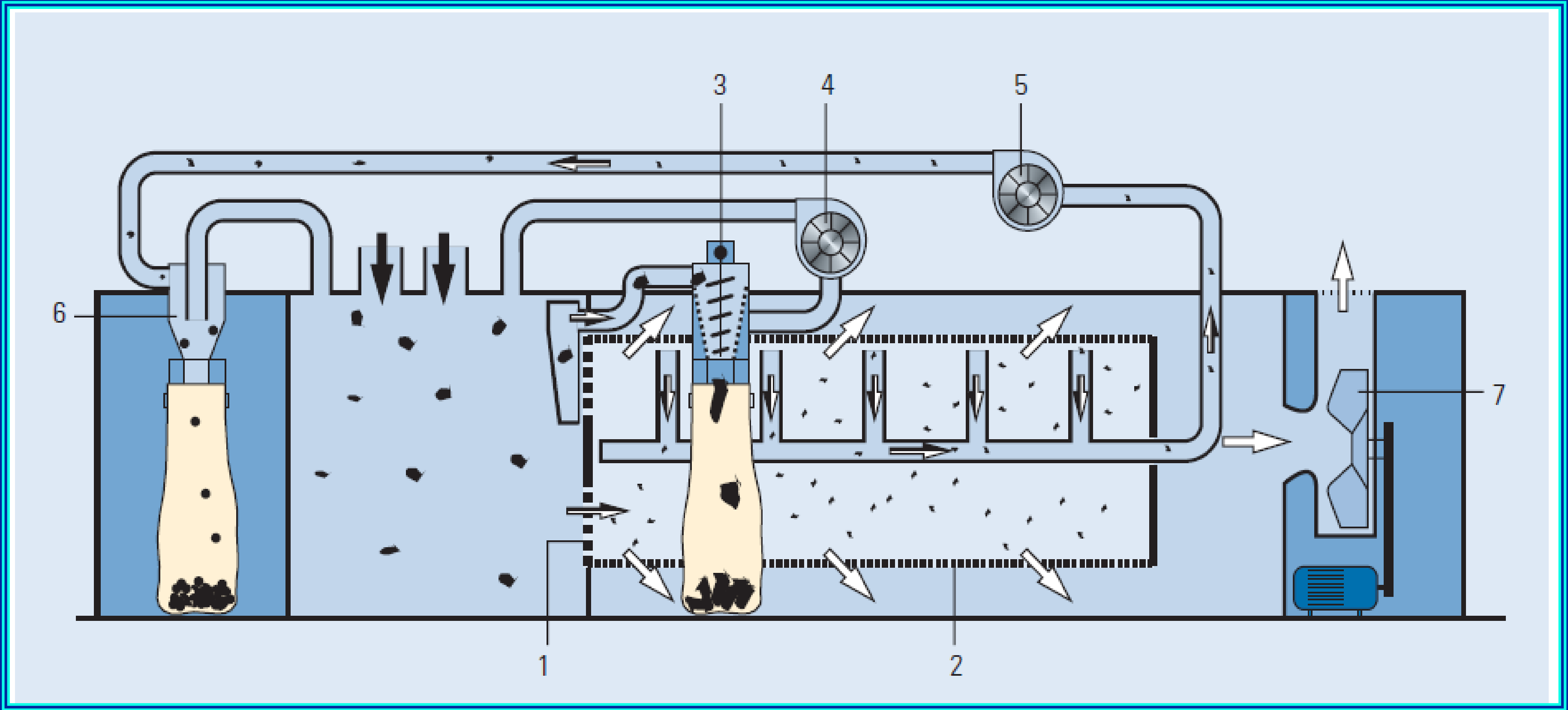


CONTIFEED monitors the material flow between two machines, a cleaning or opening line, or between a cleaner/opener and the cards.



1) Maintenance-free variable speed motor
2) Controller including adjustment for basic rotational speed and target value 3) Pressure transducer

Functional principle of the filter system



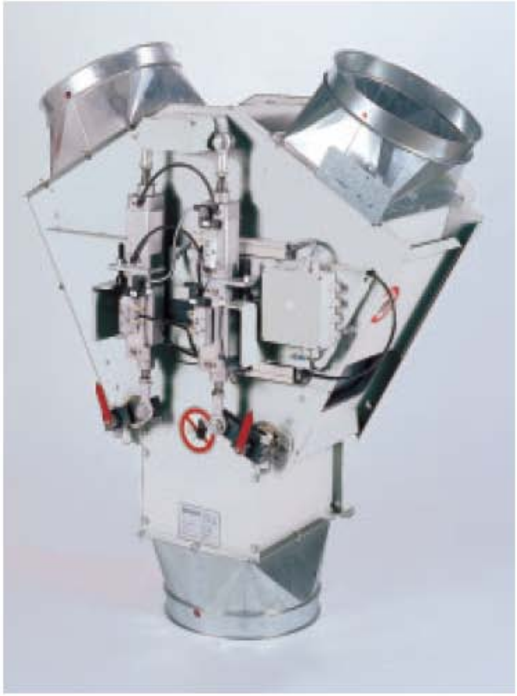
1) The pre-filter disk passes near the fixed suction nozzle while turning 2) The fine filter is fixed to facilitate filter medium changes 3) The fiber compactor compacts the waste of the pre-filter disk 4) The exhaust air of the fan returns into the filter circuit 5) The fan sucks off the fine dust from the fine filter at a very high pressure. 6) The cyclone separates the fine dust from the air 7) The fully encapsulated main fan runs in the clean air area

Pneumatically operated change box BR-AC

It is often desired to separate or merge material flows. For this, change boxes within the ductwork are used. Depending on the requirements, these change boxes are activated manually (BR-MC) or automatically (BR-AC) In any case, the position of the flaps is monitored by the installation control. When distributing the material flow e.g. into two cleaning lines, the two-way distributor BR-2W is used. Depending on the requirements, this unit feeds the material fully automatically into one or parallel into two ducts. The amount of material led to the right or to the left side can be different. It is even possible to distribute the material into three ducts by the arrangement of 2 two-way distributors in series. A typical example is the selectable bypass of a machine.

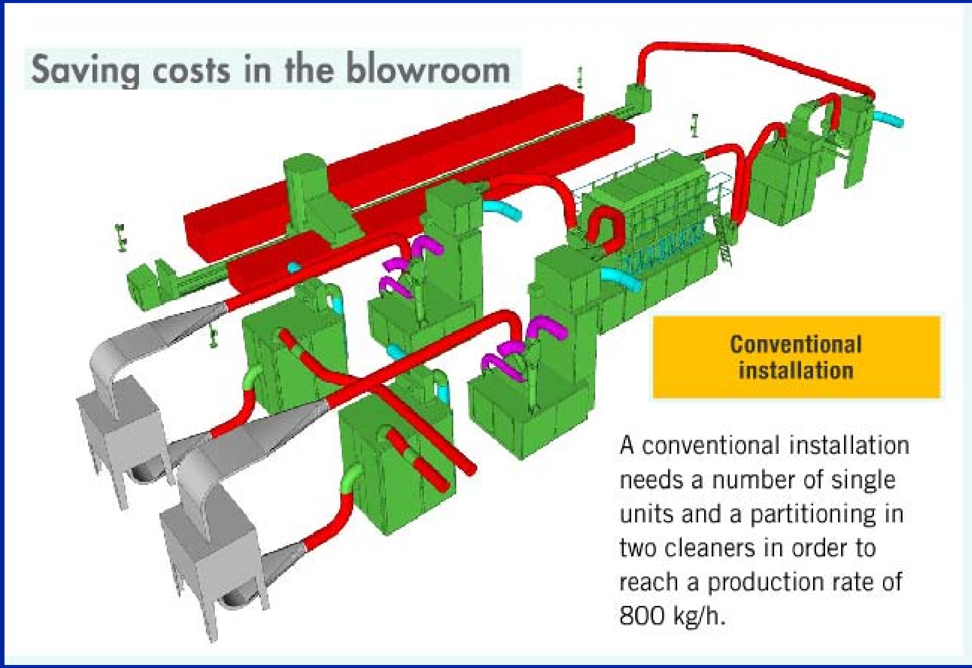
Fan BR-F

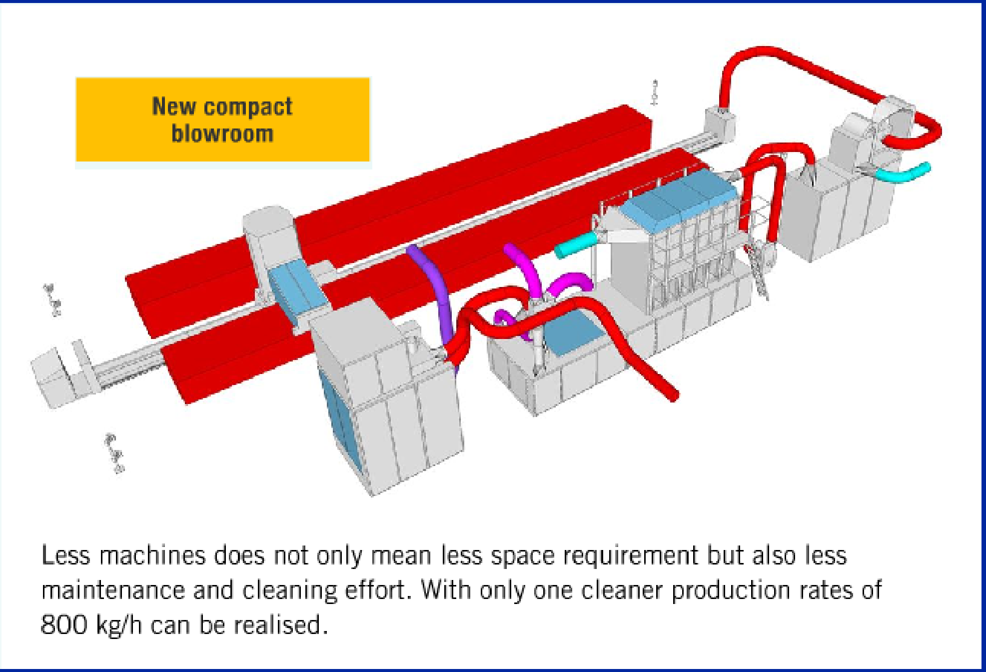
Pneumatically operated change box BR-AC



Two-way distribution BR-2W

Conventional and new Compact Blow room





The most flexible installation for 600 kg/h Three different qualities can be processed on this installation simultaneously:

Automatic bale opener for cotton processing Automatic bale opener for polyester Manually fed bale opener for a second manmade fiber component, e.g. acrylic or viscose The cards can be flexibly assigned to the three fibers By using blending draw frames also fiber blends are possible simultaneously When using the installation in the rotor spinning mill one draw frame passage can be dropped

The shortest installation for 800 kg/h The entire blowroom is composed of only four elements: Automatic bale opener BLENDOMAT Multi function separator Mixer/cleaner-combination Foreign matter separator Combination card with integrated draw frame for rectangular can delivery.

More than 80 % of all world-wide cotton qualities can be processed on this universally applicable installation.

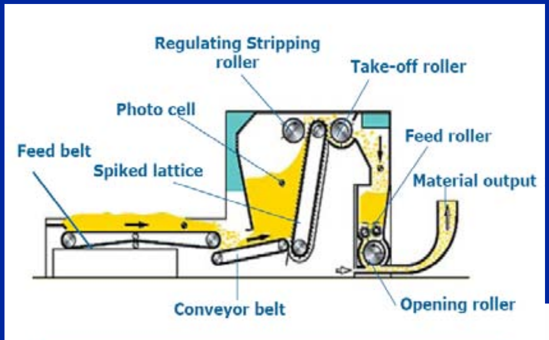


Figure 8.3: Bale opener CS with opener FO

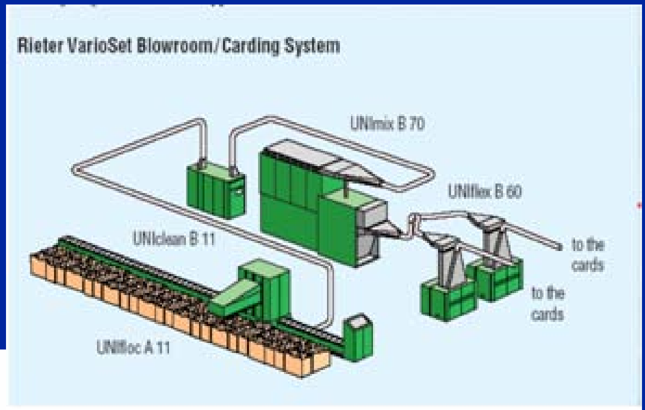
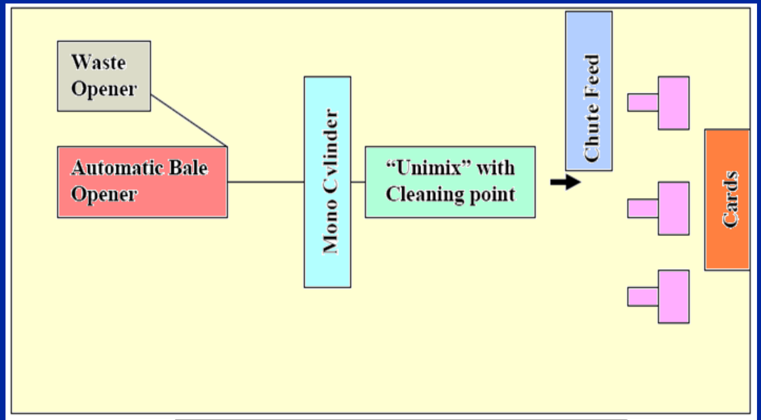
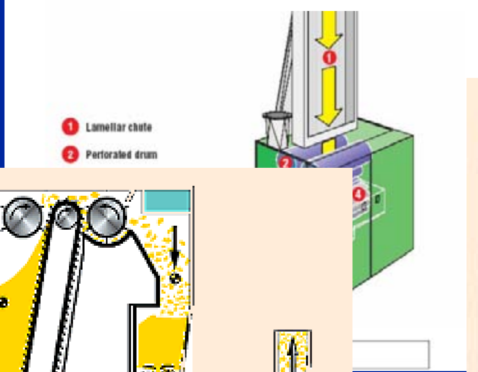
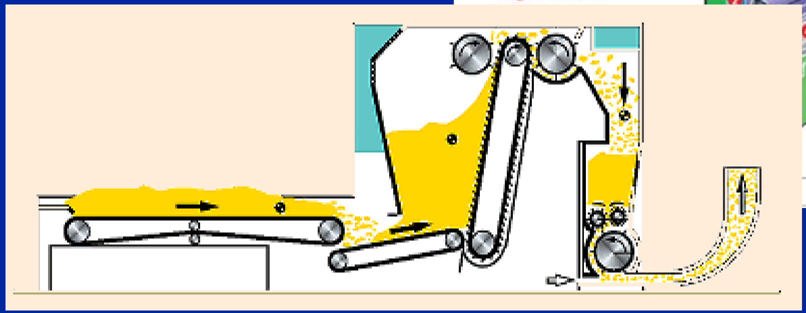


Figure Layout of typical blowing room of Rieter

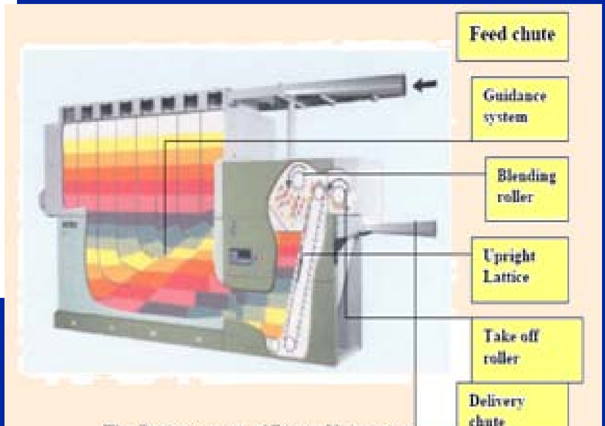


Example of Rieter Cotton Opening and Cleaning Line





Bale opener CS with opener FO



The Basic concept of Rieter Unimixer

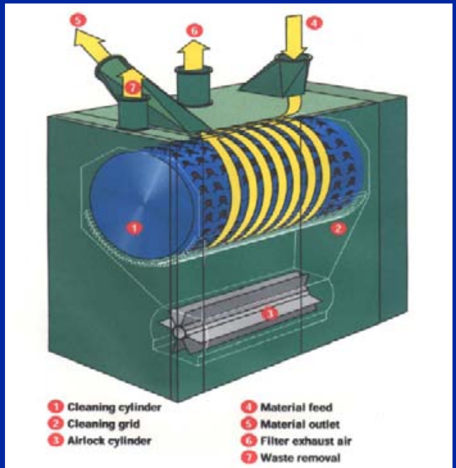
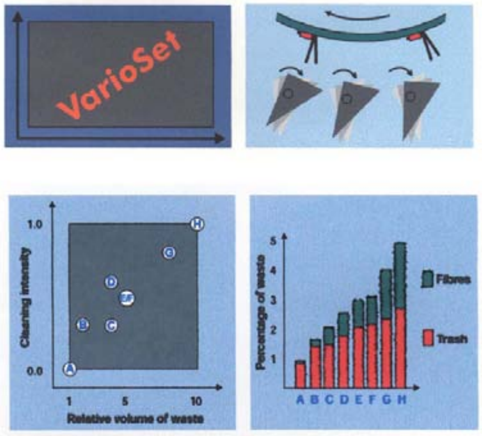


Figure 8.6: Rieter UNIcleaner B11

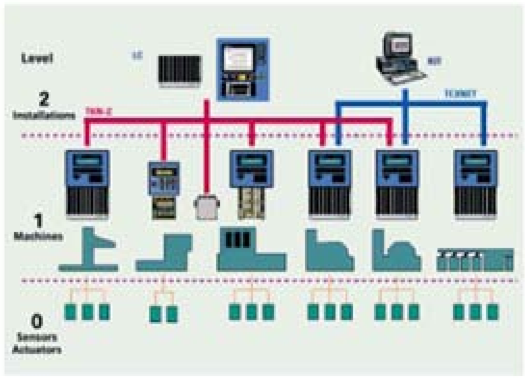


Practical example of settings on the VarioSet and their effect on waste volume and waste composition.

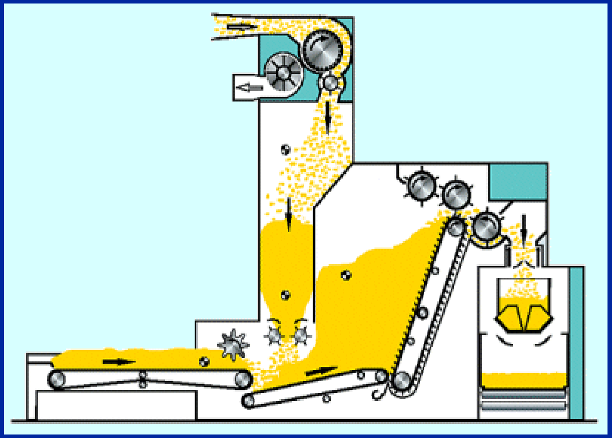
Example: card control CARDCOMMANDER

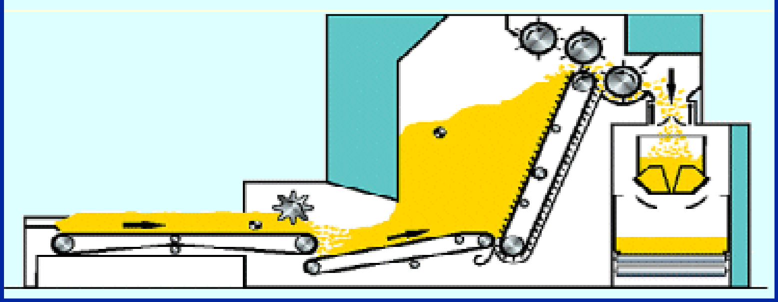
Installation control LINECOMMANDER LC

Installation controls



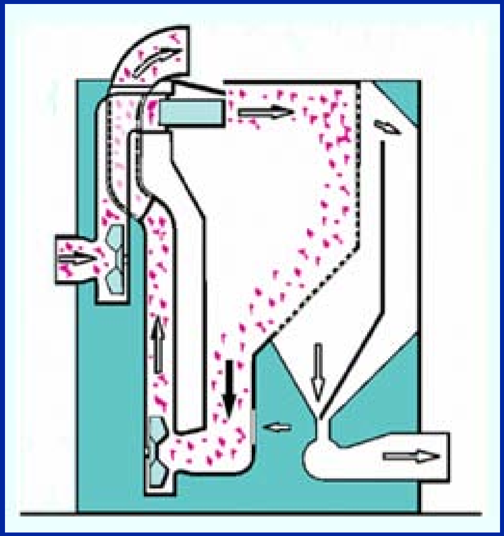
Trützschler hierarchical control ladder



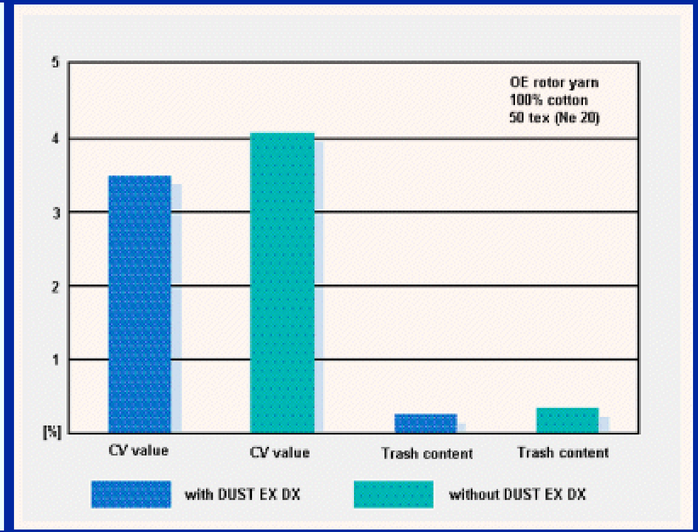


Bale opener CS with opener FO

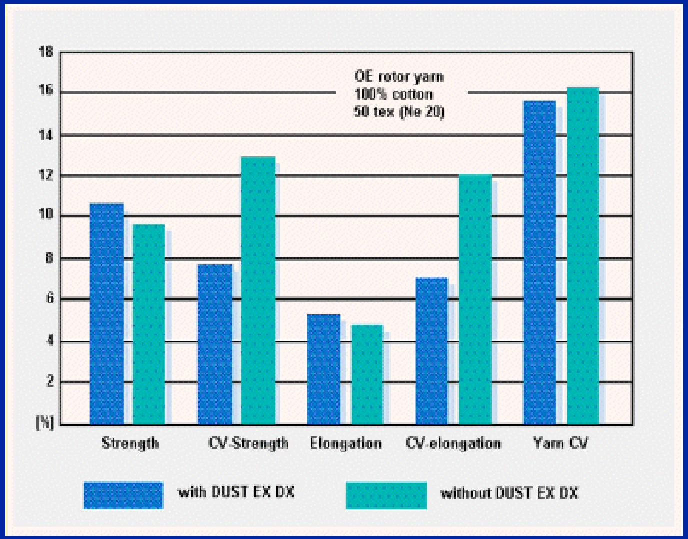
Dedusting system



Dedusting machine Dustex DX

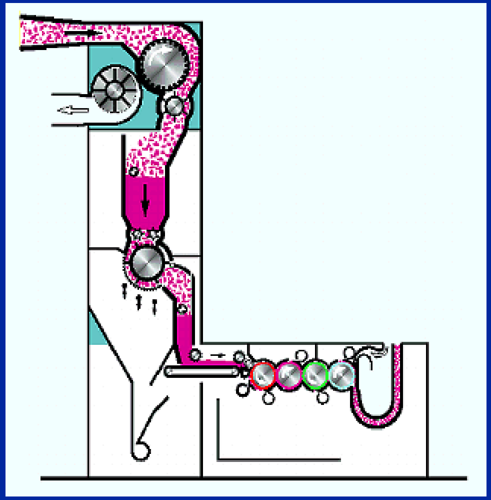


Quality of the card sliver

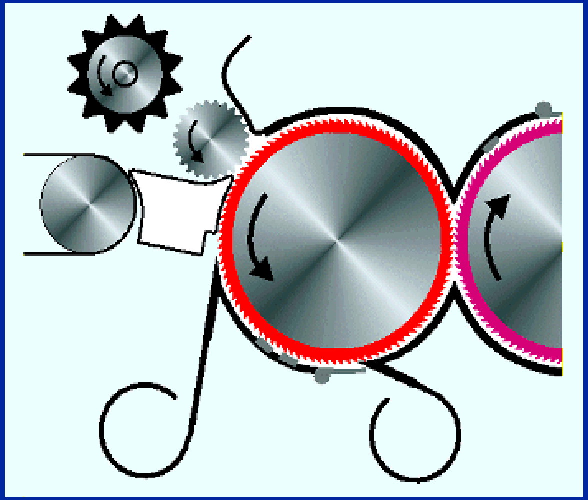


Yarn quality

Recycling installations



Waste cleaner
WASTEOMAT WST4



Feeding system of
WASTEOMAT WST

Degree of opening and cleaning systems I

Intensity of opening, I: **can be defined as the amount of fibrous mass in mg per one striker of a beater for a preset production rate and beater speed.**

$$I = \frac{p.10^6}{60 n_b N}$$

Where I **is the intensity of opening,** p **= production rate** $(Kg\,h^{-1})$ **,** n_b **beater speed** (min^{-1}) **and** ***N = Number of strikes/min***

The intensity of opening is an estimate of the tuft size produced by a given beater and from the ***I value we can get an approximation of the number*** **of fibers,** n_f ***comprising a tuft produced by a given beater.***

$$n_f = \frac{I.10^5}{L_f.T_f}$$

Where L_f = *average fiber length (cm);* T_f = *average fiber linear density (millitex).* An alternative to tuft size is the number of blows per kg, N_k .

$$N_k = \frac{1}{p}[60.n_b.N]$$

Although the ***I or*** N_k ***value gives an indication of the degree of treatment, in*** **that the more blows per kg of material the smaller the tuft size and the more trash likely to be removed, the calculation does not take account of the effect of the space settings of beater to feed roller, beater to grid, grid spacing, and beater to deflector plate. The mechanical removal of trash and dirt particles is always accompanied by some loss of fiber; with cotton cleaning the amount of fiber in the waste is referred to as the lint content. Usually this is composed of short lengths of broken fibers but poor processing can cause the loss of fibers of much longer lengths and/or a high level of fiber breakage. The objective is to optimize the machine settings, i.e., beater speed, production rate and gap settings of the working components to minimize the percentage lint and useable fiber length in the waste.**

Degree of opening and cleaning systems II

Degree of Openness value, OV

The more effectively the material is opened, the better the chances of trash removal and the lower the fiber content of the waste. The opening action primarily does two things. It reduces the fiber mass into small tufts, as described earlier, but it also loosens the tightness of packing of the fibers within each tuft, thereby reducing the tuft density or increasing its specific volume; in common parlance we could refer to the tufts being more 'fluffed up' which describes their visual appearance. The openness value (OV) is a measure of how 'fluffed up' the fiber mass has become on passing through a beater system, i.e., the effectiveness of the degree of opening.

Szaloki describes a simple method of measuring the specific volume for cotton and short-staple man made fibers. A sample of the fibrous mass is used to fill a 4000 ml Pyrex beaker. A Plexiglas disc, weighing 200 g, with air-escape holes and of a slightly smaller diameter than that of the beaker interior is placed on top of the sample in the beaker. After a settlement time of 15–20 seconds the compressed volume is noted, the sample weighed and the specific volume in units of cm^3g^{-1} calculated. Eight to ten measured samples are usually required. Measured values show a typical OV for the fiber mass in a bale of cotton at the beginning of an opening and cleaning line to be around 51 cm^3g^{-1}, whilst at
the end of the line the OV can be greater than 140 $cm^3\ g^{-1}$.

Another method is weighting of individual tufts. Also the falling time was used, where individual tufts free falls in a chute of 2 m height, and the time is measured. Further method was used where air is blown under a tuft the speed of air is increased till the tuft begins to fly. These methods are time consuming and rarely used.

Degree of opening and cleaning systems III

Cleaning efficiency (CE) and effective cleaning (EC)

The cleaning efficiency (CE) is the percentage of the impurities removed from the fiber mass. Hence,

$$CE = 100\frac{[W_{in} - W_o]}{W_{in}}$$

Where W_{in} *and* W_o *are the mass values of the impurities in the feedstock and* the processed material, respectively at the input and output to a machine or a sequence of machines, and CE is the cleaning efficiency.

the effective cleaning (EC) of a machine or a sequence of machines as

$$EC = 100\frac{[W_T - W_F]}{W_T}$$

W_T *= mass of waste;* W_F *= mass fiber in the waste.*

Basics Blending/mixing

The operation of a stack blender is depicted in the figure. The basic principle of stack blending is to fill, sequentially, a series of vertical compartments in a storage bin (providing stacks of tufts), and then to remove layers from consecutive stacks in a manner that sandwiches the layers, thereby dispersing and mixing tufts, say, from the first traverse of the bale lay down with tufts from subsequent traverses. The figure shows a stack blender of six vertical bins, referred to as a six fold mixer; a four fold mixer would comprise four vertical bins, and so on up to a ten fold mixer.

As the figure illustrates, whilst fiber tufts are being deposited into the bins, previously accumulated tufts are dropped simultaneously onto a moving belt. With the movement of the belt towards the exit of the blender, the drops from the first bin forms the first layer that receives the deposits from the second bin, which forms the second layer, and this in turn receives the third deposited layer from the third bin. This sequences of deposition eventually forms a sixth layer accumulation that is continuously fed to an intensive opener and cleaner (the four-roller cleaner). The top left of Fig. 7.8 illustrates that significant benefits may be obtained with consecutive stack blending. There are three important reasons for blending.

1. *Reduction of the production cost. Production cost = raw material cost +* conversion cost, the latter accounting for capital, labour, space, maintenance, etc. The raw material element can account for around 50% of the production cost.

2. *Product development. Often this aspect involves blending cotton with* man-made fibers, such as cotton/polyester blends for easy care fabrics, acrylic/cotton blends for increased bulk and handle in, say, sportswear.

3. *Improvement in processing performance and/or upgrading yarn quality.* Often when lower grade cottons are being processed good blending can be critical to the downstream process efficiency and the resultant yarn quality, in terms of irregularity, strength and hairiness.

Carding Process

Introduction:

The card is the heart of the spinning mill or Well Carded is half Spun.

There is no processing stage that changes the form, assignment, condition, and composition of the cotton so strongly as the carding process does. Opened and cleaned materials arrive at the carding stage in the form of small tufts composed of entangled fibers. the purpose of the carding stage is to disentangle these tufts into a collection of individual fibers, the collection being in the form of a web of fibers, and then to consolidate this collection into a sliver. Rate of production and quality should be optimized.

High production → Reduction in quality

Production rate increased since 1965 from 5 kg/h to 100 kg/h

Concept of carding machine is unchanged since 1770

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.***

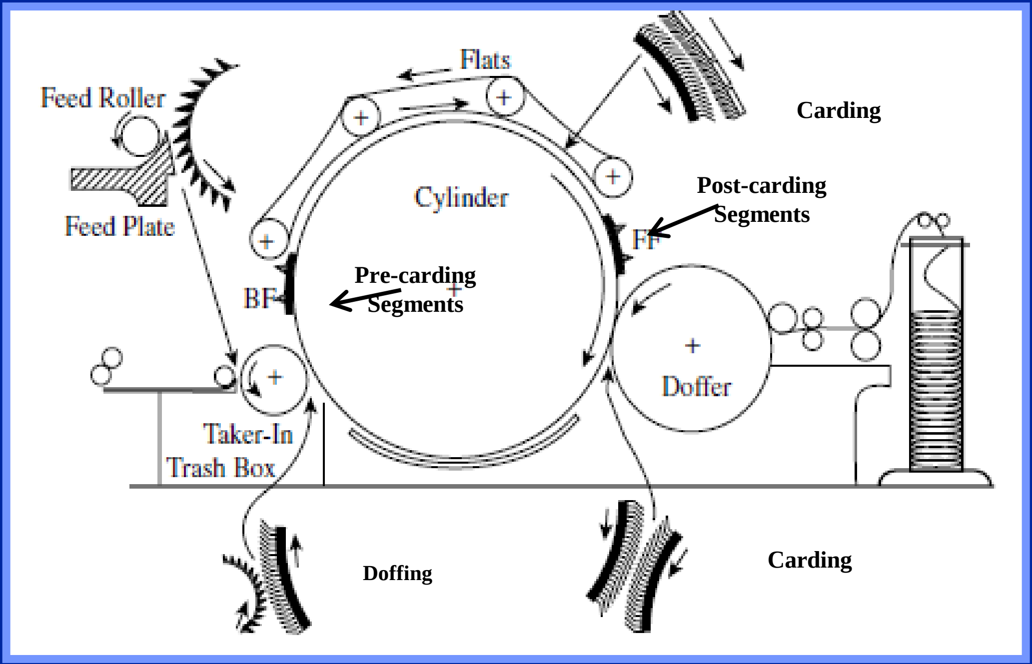
THE TASKS OF CARD

Opening to individual fibers, Elimination of impurities, Elimination of dust, Disentangling of neps, Elimination of short fibers, Fiber blending, Fiber orientation, Sliver formation.

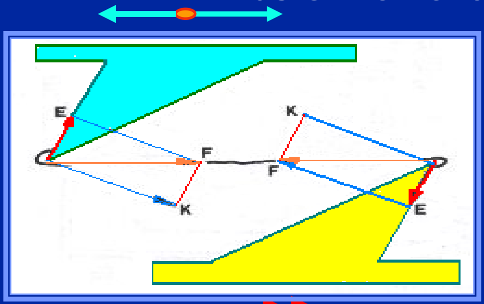
Three types that are of importance in the processing of:

cotton, wool and man-made fibers: 1.revolving flat card , 2.worsted card, 3.woolen card .

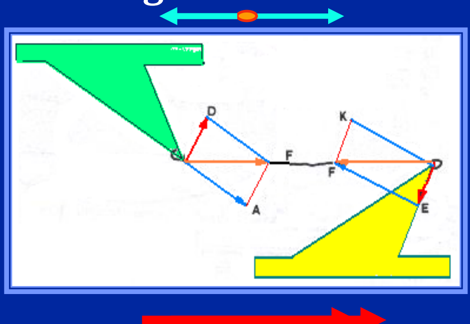
THE REVOLVING FLAT CARD



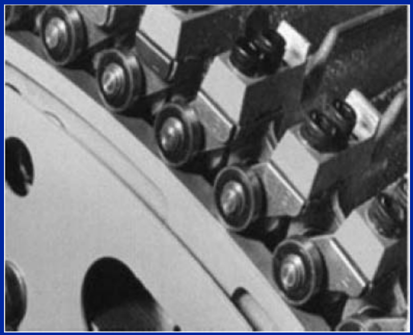
Basic Elements of carding Machine



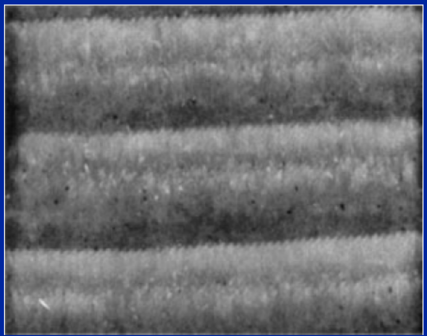
Carding action



Doffing action



Revolving flats



Cotton flats strip

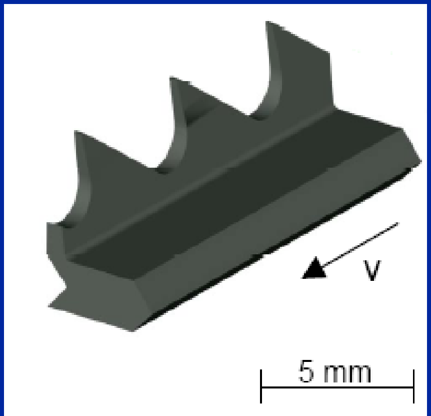
Card Dimensions

Example of Dimensions and Relative Settings of Revolving Flat Card

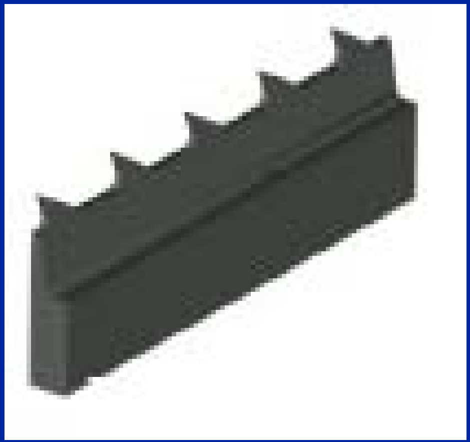
Component	Diameter in mm [in]	Tooth density in pp/cm² [pp/in²]	Speed	Draft	Approximate settings in µm [in]
Taker-in (licker-in)	229 [9] over wire 248 [9.75]	7–8 [40–50]	800 rpm	1000	Taker-in/cylinder 25 [0.010]
Cylinder	1270 [50]	62–100 [400–650]	300 rpm	2.08	Cylinder/flats 25 [0.010]
Flats	44.5 × 1016 [1.75 × 40]	90–100 [600–650]	101.6 mm/min		
No. of	106–110				
Doffer	686 [27] over wire 705 [27.75]	100	16–40 rpm	15–35 times slower than cylinder	Cylinder/doffer 12.5 [0.005]

Card Clothing

Saw teeth wire

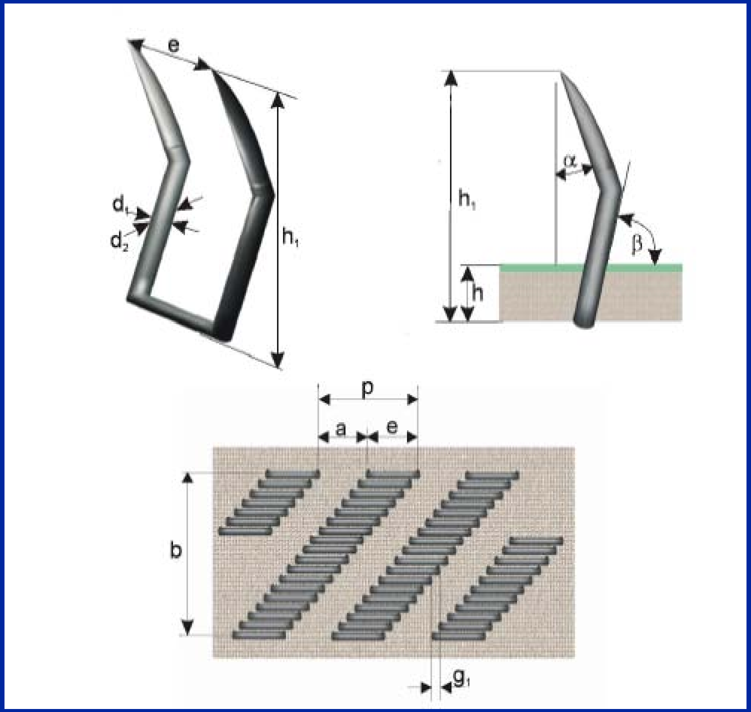


Taker in



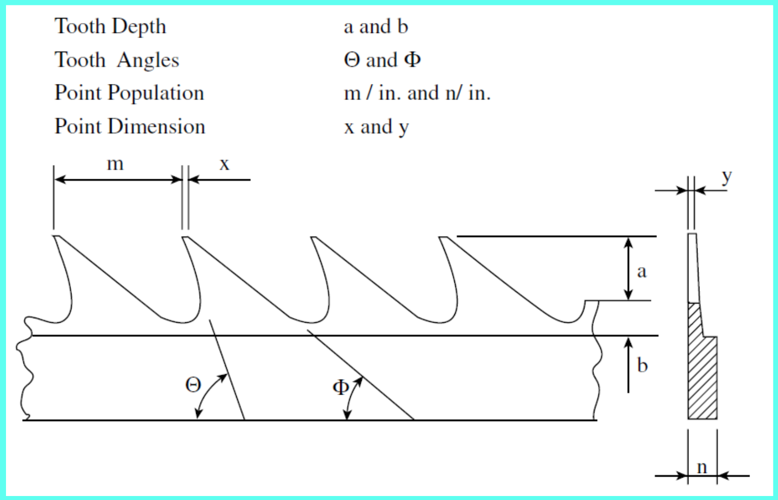
Cylinder

Flexible wire



Card Clothing

Two types of card clothing are used today: flexible or fillet wires, and saw-tooth wires (commonly called metallic wires). Historically, flexible clothing was the first to be fitted to all card components. Metallic wire became prominent in the early 1960s with the increase in production rates from 5 to 20.5 kg/hr of cotton cards. Fillet wires tend to require regular cleaning (termed stripping and fettling) to remove trapped waste fibers, whereas metallic wires dispense with this requirement. The use of metallic wire rapidly spread into worsted and semi-worsted carding as economics underlined its non-fettling advantages.



a. is the depth of the tooth. Cylinders, swifts (for wool), and stripper wires should have short working depths so as to prevent high fiber loading and to keep the fiber at the tip of the tooth to maximize the shear force of the carding action. Workers and doffers should have large working depths so as to hold the fiber mass for effective carding and fiber transfer during doffer web formation.

b. is the base depth of the tooth, which is usually free of the fiber mass but is important to the aerodynamic effects generated by the rotating components. Too shallow a depth can result in pressure points and fiber blowouts, producing a patchy web.

ELEMENTS OF THE CARD
Feed Material

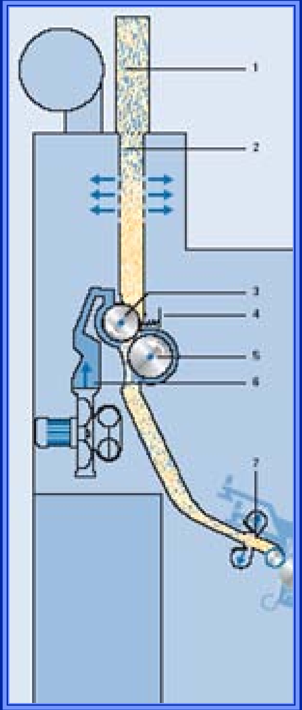
DIRECTFEED – the tuft feeder of the card TC 03

The tuft feeder DIRECTFEED is an integral part of the card. Integration into the card means that the delivery roll of the tuft feeding unit is identical to the feed roll of the card. The formerly common web transfer unit is gone. False drafts caused by wrong or not optimal settings can no longer occur. The tuft feeder works according to the double trunk principle. Further developed air separation elements in the upper trunk allow a more even feeding and more adaptation possibilities for a flexible assignment of the cards to the feeding lines. In the lower trunk, the basis for excellent sliver CV values is laid due to an optimized geometry and an extended material travel path. The air outlet combs with direct and permanent suction are positioned right in front of the feed roll of the card. It is not until here, only a few centimeters in front of the nip line of the feed roll, that the web is formed.

Better sliver evenness at highest production rates

A high material reserve in the 1200 mm wide upper trunk of the tuft feeder ensures stable, trouble-free running. Sliver evenness, too, benefits from this. The feed tray is subdivided into 5 segments, each segment is spring-loaded. In this tray, the web is clamped more gently and more effectively. The high rpm opening roll, which is equipped with rather few pins, opens the tufts gently and prevents nep formation.

1- High volume upper trunk
2- Integrated air volume separator
3- Feed roll, electrically coupled to the feed roll of the card
4- Segmented tray to secure clamping
5- Opening roll with pins
6- Closed air circuit with integrated fan
7- Self cleaning air outlet combs.



Chute feed system

Self-cleaning stainless steel comb

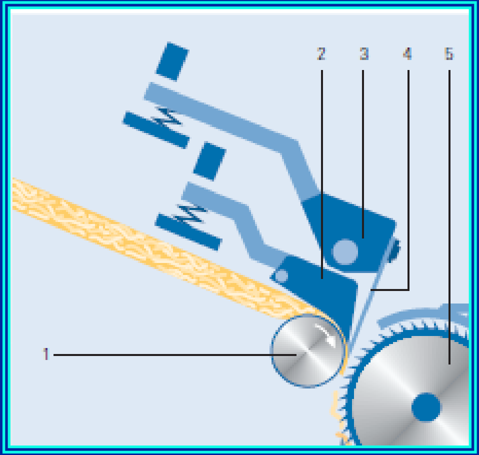
Feeding and Opening zone:

Integral feed tray SENSOFEED

The integral feed tray SENSOFEED of the TC 03 works with a feed roll, a feed table and a measuring lever. The feed table condenses the web and guides it to the spring elements of the measuring lever. This lever is equipped with 10 spring elements of 100 mm width each, which taper off to the bottom. Due to the filigree shape of the point, the spring elements guide the web in a controlled way directly to the transfer point to the spiked roll of the WEBFEED unit. Each one of these spring elements exactly adjusts itself to the momentary mass of the web to be fed. This means if there are mass variations in the web the spring elements are differently deflected. The deflections of all 10 spring elements are processed to become one average signal which is used as actual value for the short-wave levelling system.

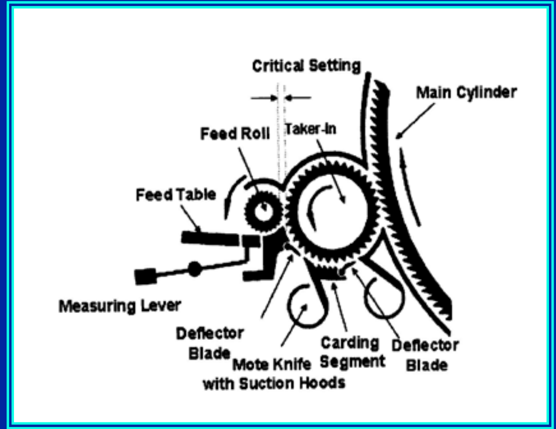
The feed system of the card TC 03

1) A special clothing of the feed roll prevents lap formation
2) Spring-loaded feed table
3) Spring-loaded measuring lever
4) Spring elements
5) First roll of the WEBFEED unit



Exact feeding through controlled web guidance

Congenital taker-in system



The weight of fiber mat ranges from 400 to 1000 g/m (ktex), this Gives about 2 to 6 millions of fibers.

The carding sliver count is 3 – 5 ktex, i.e. 40,000 fibers. This is achieved mainly between feed roll and taker-in.

Taker-in is 250mm in diameter.

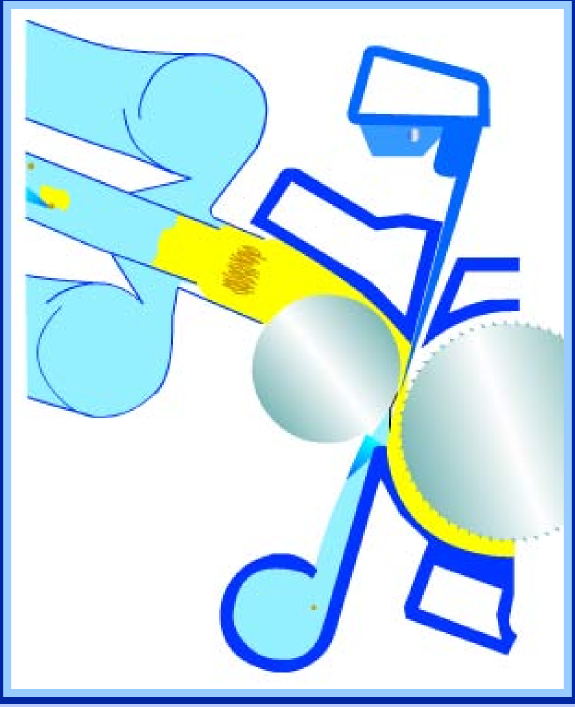
700-1000 rpm for Cotton, and 400- 600 rpm for Synthetics.

The draft is 1000

Feeding and Opening zone:

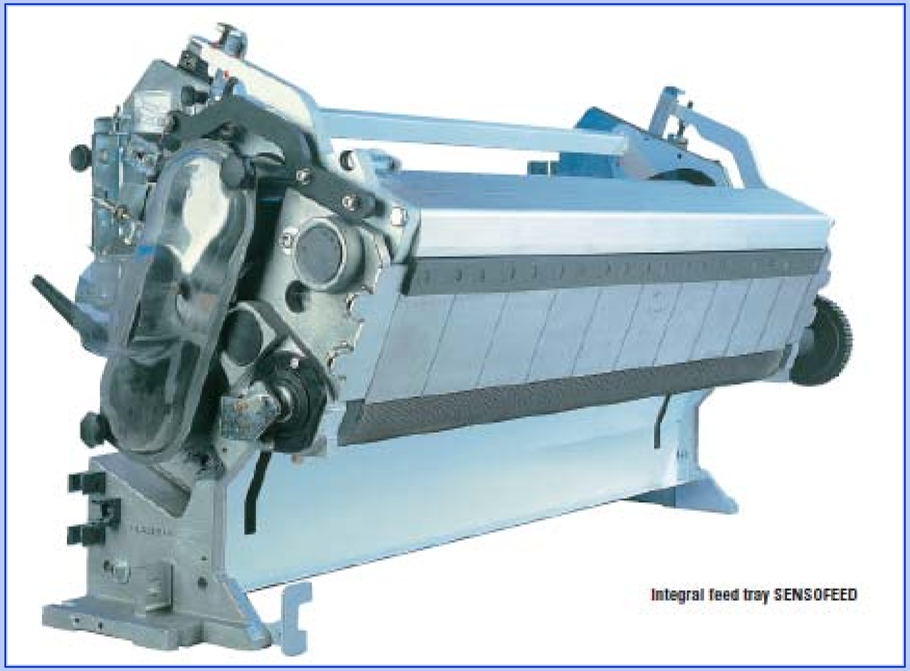
Sensofeed-Web-feed System

Integral Feed Plate SENSOFEED



The deflection of all 10 spring elements are processed to become one signal for the short-wave regulation. Thus it is possible to avoid thickness variation and to feed an even web to the Licker-in system **WEBFEED**

Integral Feed Plate SENSOFEED - the perfect feeding system for the card



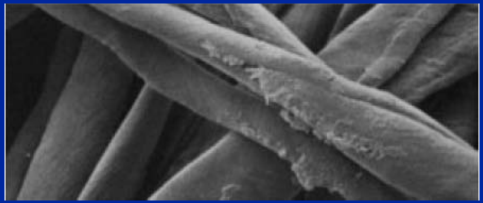
With the integrated feed plate SENSOFEED, the web is guided to the transfer point between feed roll and the 1st licker-in roll via 10 spring elements. Each spring element exactly adjusts itself to momentary mass of the web to be fed, i.e. if mass variation in the web occur, the spring elements are differently deflected.

Effect of Carding Plates

During opening, trash particles and neps are released. The pair of knife-edge plates, termed mote knives, that are positioned close to the taker-in surface assist with retaining usable fiber while ejecting the impurities through imbalance of centrifugal and aerodynamic forces. The table give examples of results obtained from mill trials with and without carding plates fitted to taker-in zone, and it is evident that significant reductions in lint content can be obtained with the use of carding plates.

Effect of carding plates

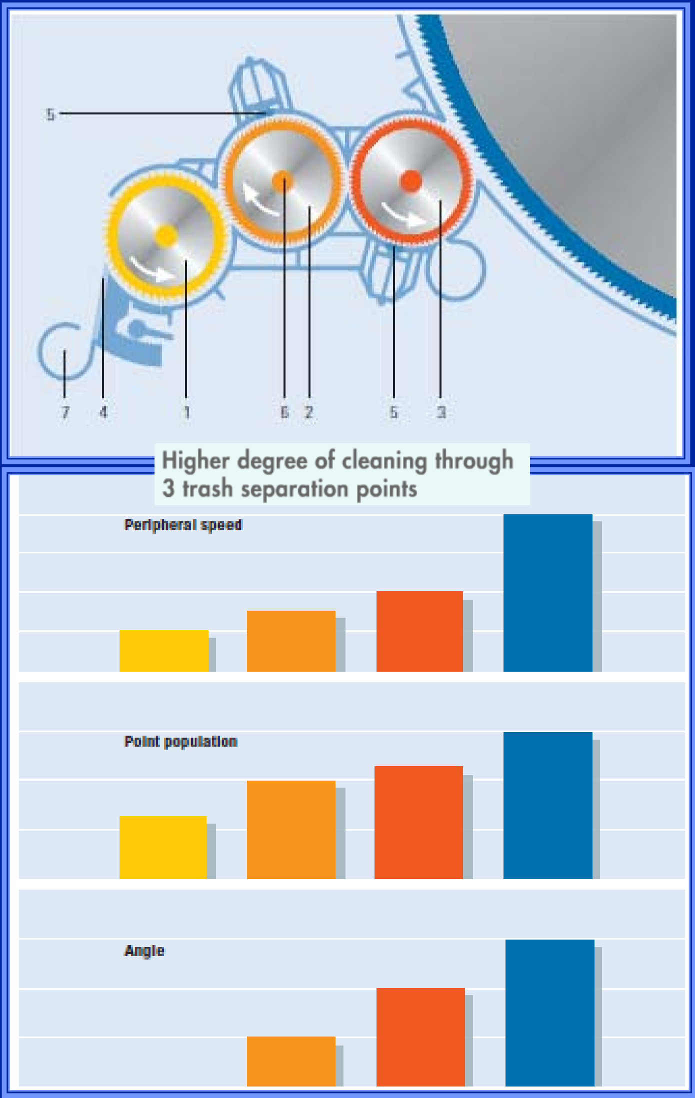
Fiber	Without	With	Difference %
Cotton waste			
• Taker-in waste, %	4.53	3.24	-2.85
• Lint content, %	2.60	1.28	-50.5
• Trash and dust content, %	1.93	1.96	+1.60
Bleached waste			
• Taker-in waste, %	*17.6*	*8.0*	*-54.5*
Cotton: strict middling			
• Taker-in waste, %	3.79	0.89	-76.5
• Lint content, %	3.28	0.68	-79.3
• Trash and dust content, %	0.51	0.21	-58.8
Egyptian cotton			
• Taker-in waste, %	2.75	1.61	-41.5
• Lint content, %	3.29	1.16	-40.4
• Trash and dust content, %	0.46	0.45	-2.20



Trash and dust particles on fiber

Licker-in WEBFEED system

Trash and dust particles on fiber



Gradual opening for a maximum fiber care

1) For processing cotton, the first opening roll is equipped with gentle pins

2) Through a higher peripheral speed the fibers are gently transferred to the following roll

3) The third roll transfers a thin web to the cylinder

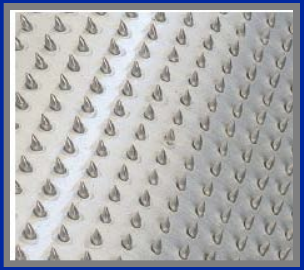
4) The position of the knife can be adjusted with one action from the outside

5) The radius of the carding segment is adapted to the cylinder geometry

6) Low-maintenance bearings

7) Optimum fitting of the WASTECONTROL TC-WCT for minimizing good fiber losses

The **WEBFEED** system consists of three opening and cleaning rolls in series arrangement.



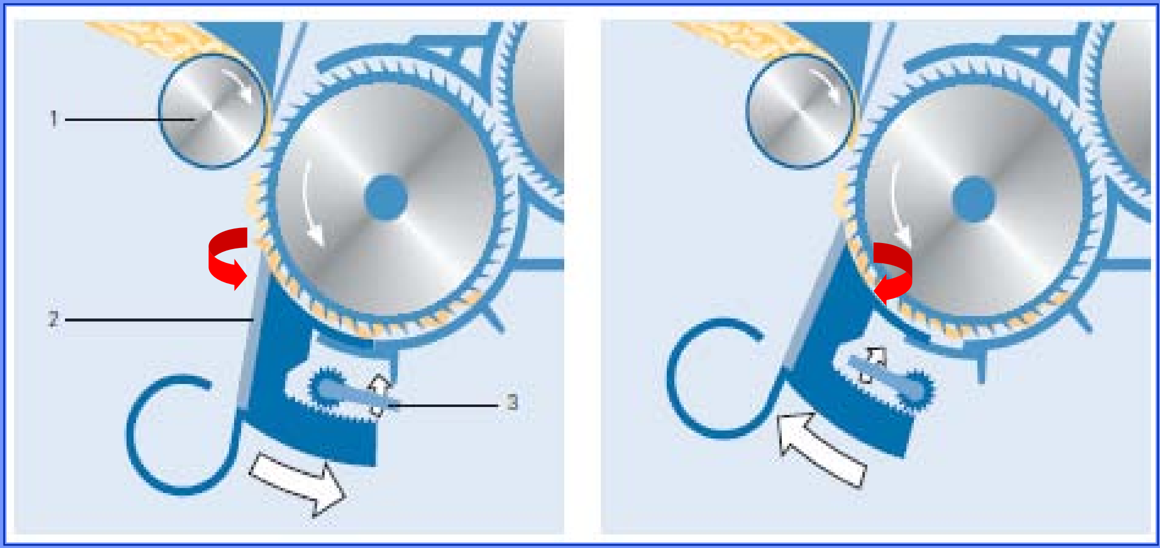
For a long life the pins of the first opening roll are made of special steel

A special gluing technique prevents the pins from dropping and the fibers from sticking to the needle base. The needle is always centered. The pin is exactly guided.

Mote Knife Setting

Precision Mote Knife Setting System PMS

Through the circular adjustment, the top edge of the knife always remains at an optimum distance to the pins



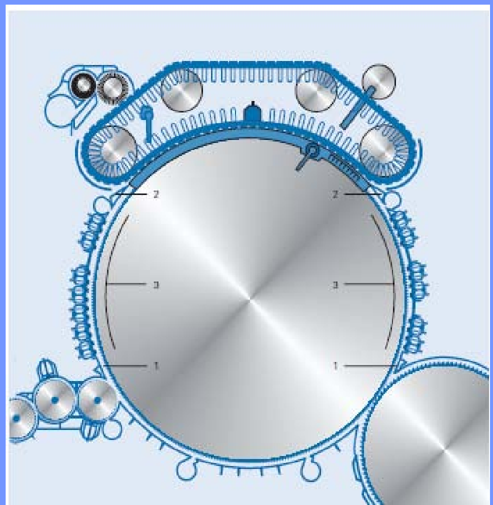
1) Feed roll
2) The adjusting slide moves with the knife on a circular path around the centre of the pinned roll
3 With this lever the position of the knife is adjusted in no time.

The mote knife remains always in the optimum distance to the needles due to circular setting. Knife adjustment is possible while the machine is running The card must not be stopped, as the setting lever is positioned on the left side of the machine which is freely accessible. Adjustment is possible even during production. A view into the transparent suction ducts immediately shows the success of the readjustment. As the lever is fixed at the free accessible left side of the machine, the adjustment of the mote knives is possible with a running machine.

MULTI WEBCLEAN system

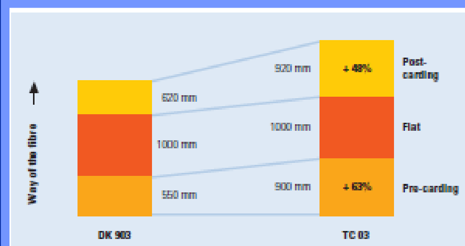
Production and quality increase

An exemplary configuration of the MULTI WEBCLEAN system for polyester processing

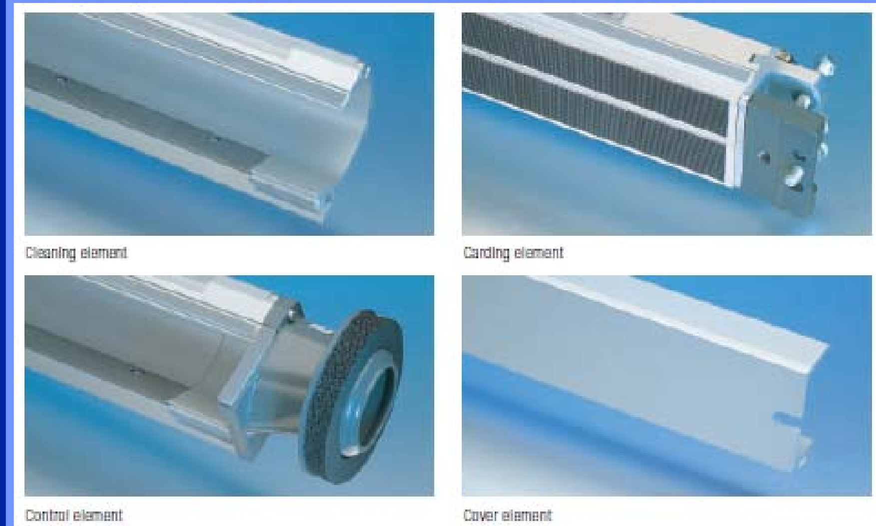


1) Fixed execution cover section
2) Fixed execution cleaning element
3) Flexible execution for 8 elements each

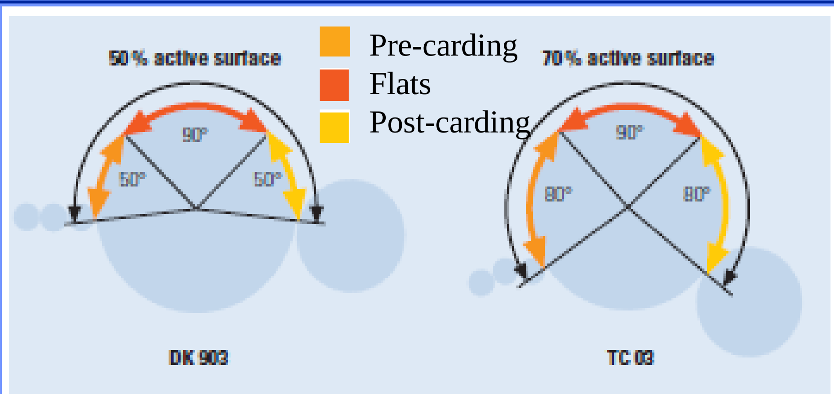
Increasing the carding zones



different elements of the modular system



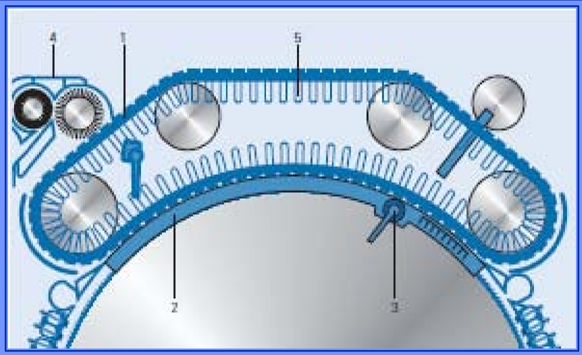
The active clothing area of the cylinder has been increased



WEBFEED unit and the doffer below the cylinder, more room has been made for the functions of pre-carding and post-carding. In the pre-carding and in the post-carding area of the cylinder, 10 special elements of the MULTI WEBCLEAN system can be mounted in most different combinations. In each case, the first and the last elements are fixed. For the remaining 8 positions the following elements can be flexibly used, depending upon the task:

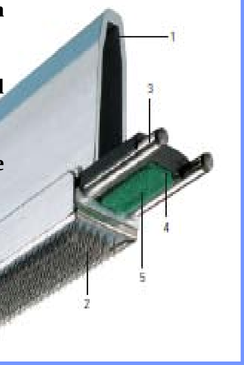
1. **Cleaning element: This element consists of a mote knife with a hood under permanent suction.**
2. **Carding element : A number of different clothing types and point populations are available depending upon the installation site and the raw material.**

Flat setting system

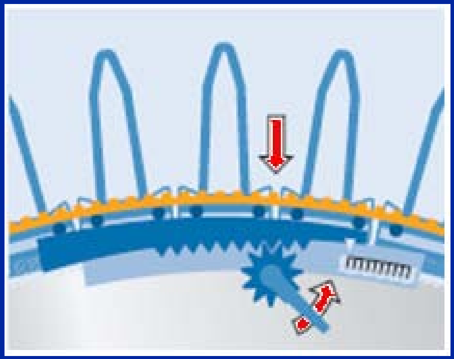


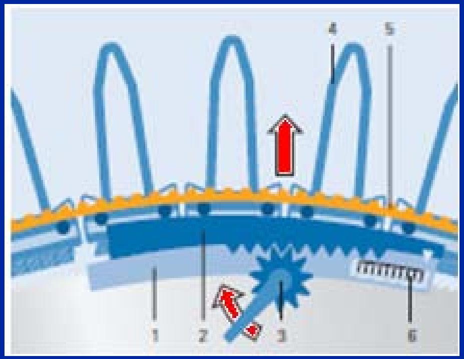
1 Special timing belt with cams for clipping in the flat bars
2 Precision flexible bend with 6 setting points
3 Precision flat setting system PFS
4 2-roll flat cleaning device
5 Aluminum flat bars exchangeable without tools

1 Optimized, light aluminum profile
2 Securely fixed flat clothing
3 Wear-resisting hard metal gliding pins
4 Plastic fixing clips
5 The cleaning felt keeps the sliding surface clean



The individual flat bars are made of aluminum profiles and are thus light and extremely stable. They are guided by two timing belts to which they are connected through a cam without further fastening elements. The hard metal pins fixed to the ends of the flat bar glide across a special plastic strip. A full flat exchange can be done by just one person in less than an hour. As there is no oiling or greasing the whole flat area remains clean and maintenance-free. By using the hard metal gliding pins, reshaping the flat heads – otherwise necessary after re-clothing – is a thing of the past.





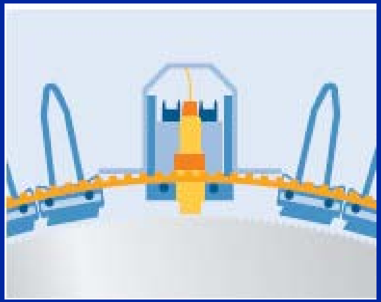
1) Metal flexible bend 2) Wear-resistant special plastic slide rail 3)Setting lever 4) High-precision aluminum flat bars 5)Cam timing belt for the flat drive 6)The setting can be read directly from a scale

At each side of the card, a small gear is turned manually or by motor. In the case of a manual adjustment, a scale shows the actual setting in relation to the basic setting.
In the case of an adjustment by motor, the position is chosen and shown on the display of the machine control.

FLAT CONTROL

With the FLATCONTROL TC-FCT, Trützschler offers a system for the quick and exact measurement of the distance cylinder/flats. A better card sliver quality and longer clothing life are the main advantag

Better card sliver quality due to reduced setting tolerances, Extension of clothing life, Quick flat setting, Reproducible, objectively checkable settings, Flexible applicability, and Independent of personnel influence



For the time of the measurement three normal flat bars are replaced by a measuring flat

FLATCONTROL TC-FCT is also a good aid for the basic adjustment of the flats. The measuring flat is exactly moved to the respective setting position. The distance to the cylinder is graphically represented on the computer's color screen. The technician can now – with only one glimpse at the screen – adjust the distance between flat and cylinder more exactly in a few seconds than would ever be possible using feeler gauges.

A sensor at each side measures the distance to the cylinder

1) Distance sensor 2) The hard metal pins glide on the plastic strip of the flexible bend

Measurement over the total flat area

For the measurement three normal flat bars are replaced by the FLATCONTROL measuring flat. The sensors in the measuring flat determine the distance to the cylinder clothing while the measuring flat moves about the working range. The microcomputer in the measuring flat stores all measuring values automatically. After a series of measurements the values are transferred to a portable PC and graphically represented.

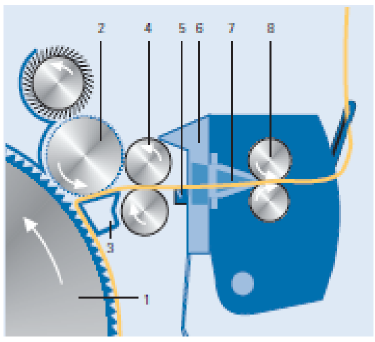
Web doffing unit

The individual fibers attached to the cylinder clothing collectively appear as a very light web on the cylinder surface. This web moves with the cylinder rotation and first comes into contact with the front fixed flats, which further extract neps and fine trash particles and comb the fibers. It then comes into contact with the doffer clothing, which removes the fibers from the cylinder by the point-of-tooth to point-of-tooth (carding action) stripping action is due to condensing. This cylinder-doffer area is called the transfer zone, since the objective is for fibers to be transferred from the cylinder to the doffer. Not all the fibers, however, are stripped on first contact with the doffer; some remain on the cylinder for several cylinder rotations before being removed. The cylinder under screen controls the boundary air layer at the cylinder surface to prevent the un-doffed fibers being ejected from the cylinder clothing during their motion from the doffer/cylinder area to the taker-in/cylinder area. Some reports that there appears to be an optimal number of times fibers should go through the transfer zone before being stripped by the doffer; too short or too long a dwell time on the cylinder impairs the quality of the output material, i.e., the sliver.

Self-adjusting and maintenance-free seals on the sides of the cylinder prevent a contamination of the critical zones. sliver former WEBSPEED
forms the web to a sliver and guides it to the measuring funnel. In order to allow an optical assessment of the web quality or to take samples, the sliver former can be opened by pushing a button. For processing extremely short fibers the card can optionally be equipped with a transverse sliver take-off system.

Visual web inspection is possible by pushing a button

WEBSPEED



1) Fully enclosed doffers (top and bottom)
2) The stripping roll is equipped with a special clothing which prevents lapping
3)The guiding profile can be exchanged against the NEPCONTROL
4) The crush rolls ensure an even web transport

5 The web guiding bridge supports the web, particularly with high speeds
6 The sliver former WEBSPEED is absolutely maintenance-free
7 In this funnel, the sensor for sliver quality monitoring is integrated
8 The calender rolls condense the sliver to ensure its proper delivery into the can and trouble-free supply out of the can.

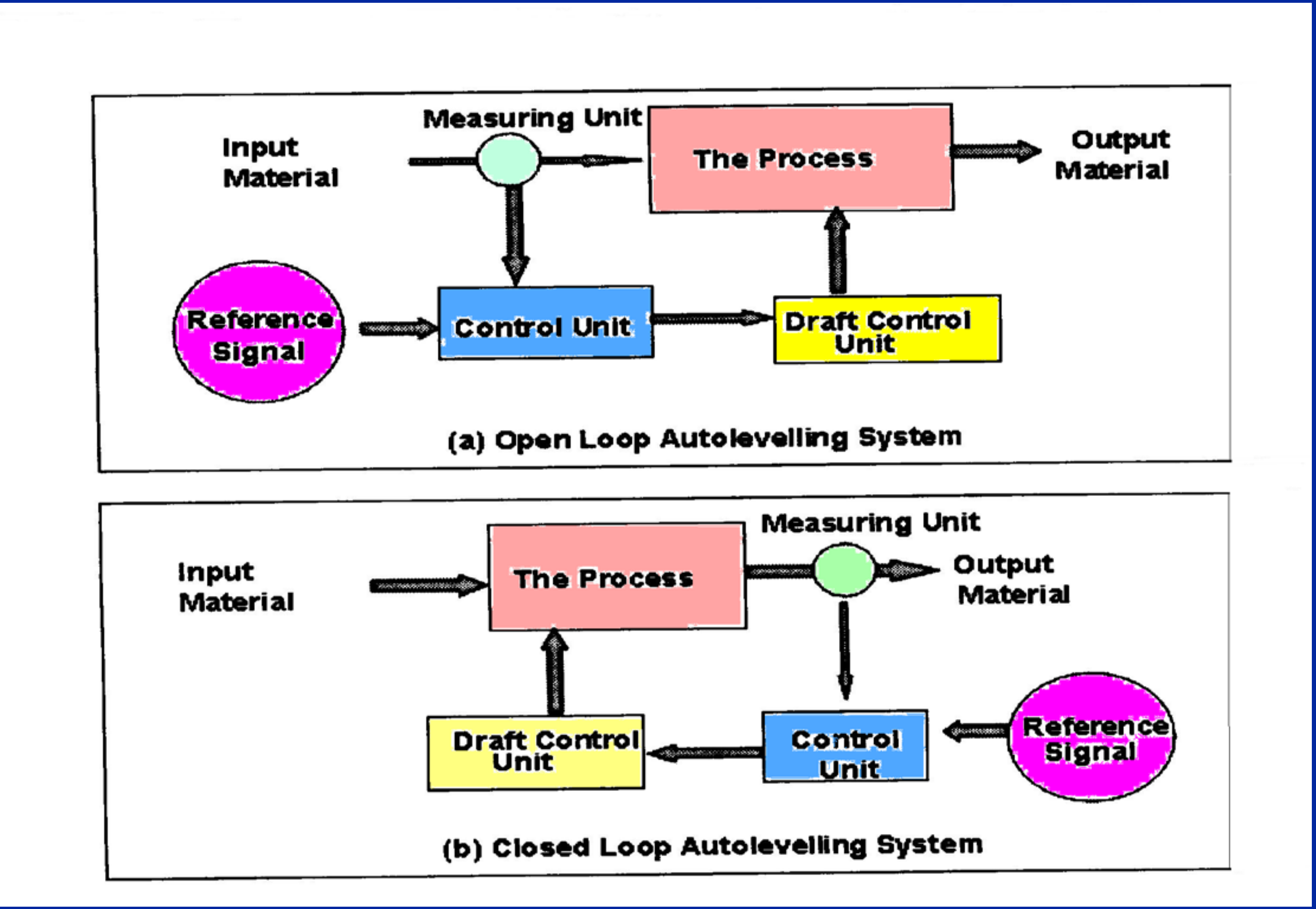
Fitting Flats Type for Different Materials

The material, geometry and dimensions of the wire are of great importance for the function of the carding machine. Different materials have different coefficient of friction, therefore choice of optimal angles is the key of successes for smooth carding process.

Tailor-made solutions

Basic of automatic control systems

Open and close loop control systems

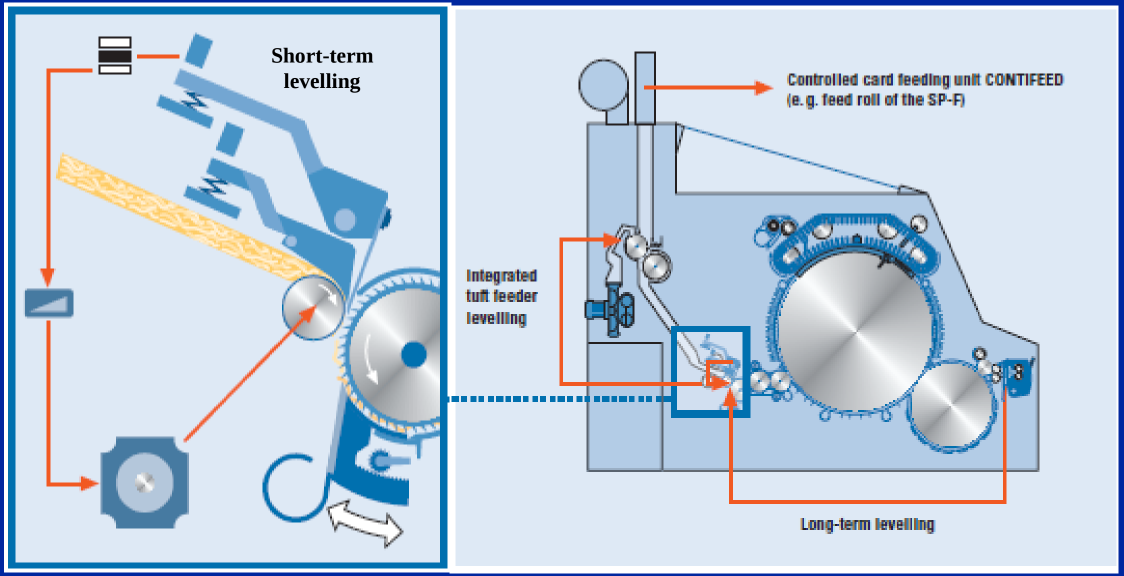


Levelling systems

Producing an even card sliver is the result of a number of measures adapted to each other

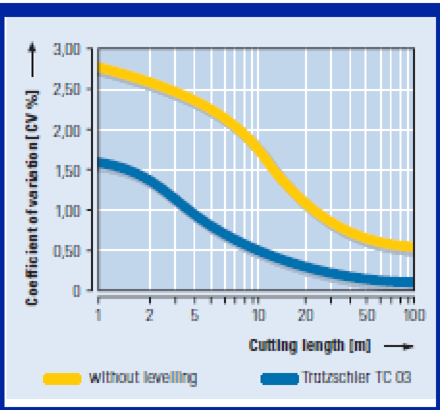
1. Card feeding: Already the material flow towards the card is continuously controlled in Trützschler installations (CONTIFEED system). The production requirements of all cards of a line determine the momentary production of the last machine in the blowroom. This continuous card feeding is the basis for an even sliver.

2. Card feeding: The double-trunk principle of the tuft feeder with its continuously pressure-controlled feeding of upper and lower trunk ensures a further homogenization. During start-up and run-down of the card, for example, speed adjustment of the feed roll of the tuft feeder to the respective card production avoids unevenness.



3. Long-term levellingL: The sensor in the sliver trumpet of the card measures the sliver thickness. The feed roll speed is controlled according to this signal. One single sensor covers the whole range of common card sliver weights.

4. Short-term levelling: The card TC 03 is equipped with a short-term sliver weight levelling. This system considerably improves the evenness of the card sliver. It even works for a sliver length of less than 1 m. The thickness of the tuft web is constantly scanned in the integral feed tray SENSOFEED. Based upon the values determined, the card control calculates a possible change of the feed roll speed. This short-term modification superimposes the signal coming from the long-term levelling system. In case of speed changes (e. g. during can change), special algorithms ensure a constantly high evenness of the sliver.

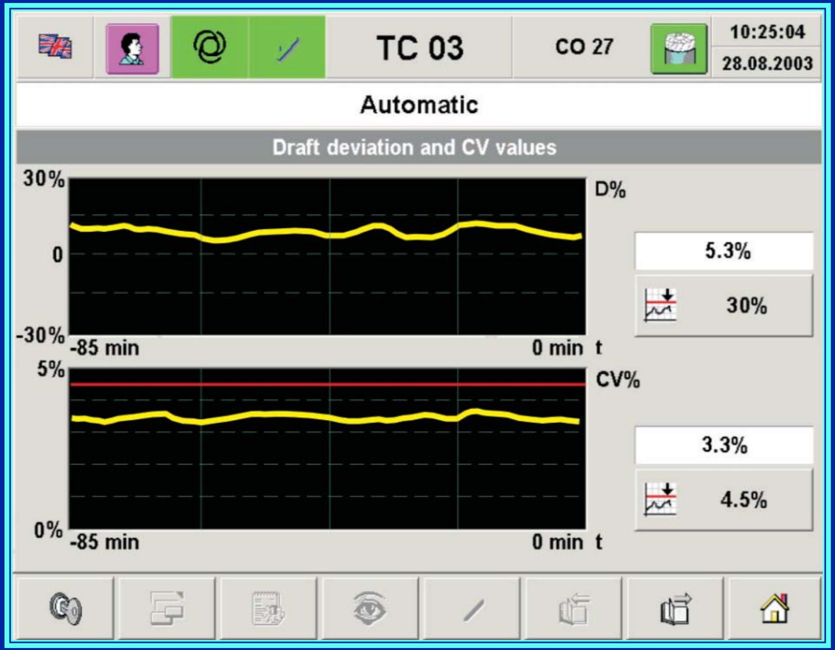


evenness values over the total length range

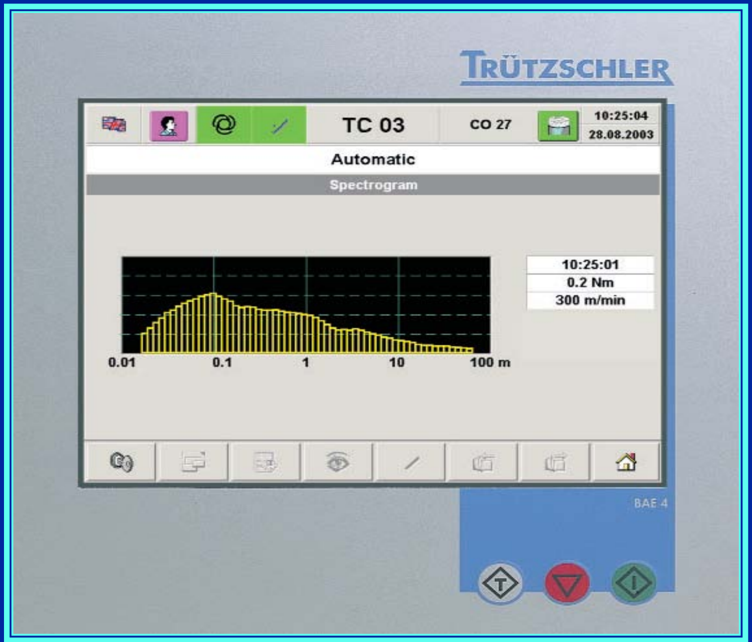
Quality monitoring

Quality control, online and permanent monitoring: modern card is equipped with a comprehensive integrated quality monitoring. Every meter of card sliver is checked prior to its delivery into the can. The sensor supplies the signals for determining sliver fineness, sliver evenness, spectrogram, frequency of thick places

The evaluation of the sensor signals is effected in the card control and the results are displayed on the screen of the control e. g. as a spectrogram. In case of deviations exceeding certain preset limits the card is automatically switched off. This permanent online production control is superior to random sample checks in the laboratory. Thick place monitoring has been integrated into the card control system.

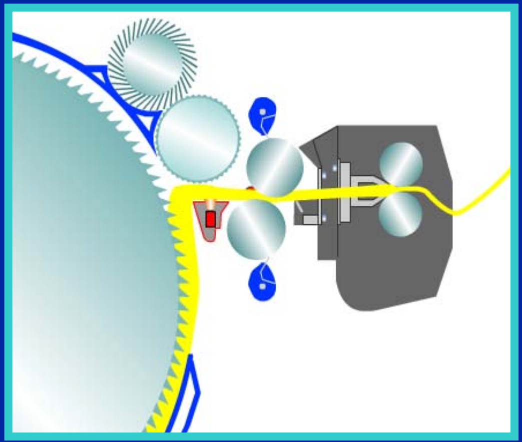


Quality data are represented in clear arrangement



spectrogram on the screen of the card

NEP CONTROL



The sensor is mounted below the stripping roll

The nep sensor is mounted to the card on a telescopic rail without any problems

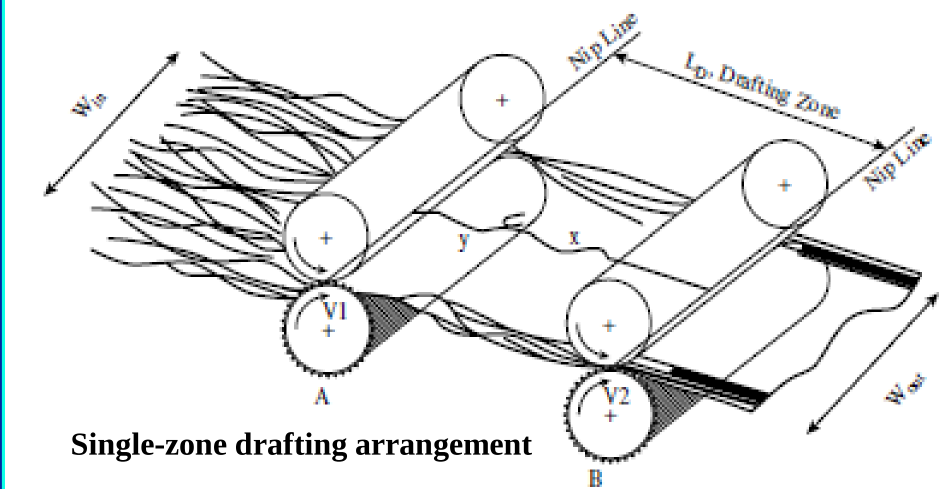
Electronic camera films the whole web. Pictures are evaluated regarding neps, trash particles and seed coat fragments by computer directly flanged to the profile

Online nep control in perfection With the NEPCONTROL TC-NCT, Trützschler offers a real alternative to costly laboratory examinations. TC-NCT monitors the card web during production and gives information about the respective quality. Personnel-intensive examinations in the laboratory are no longer needed. Every metre of card sliver is of checked quality.

Controlled nep level An electronic camera takes pictures of the web under the stripping roll. The camera moves across the whole working width of the card in a special, fully enclosed profile. This optical principle correlates best with human's visual perception and is thus superior to indirect measuring methods. The pictures are evaluated regarding neps, trash particles and seed-coat fragments by a high-performance computer directly flanged to the profile.

Drawing and Integrated Card-Drawing Machines

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 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.

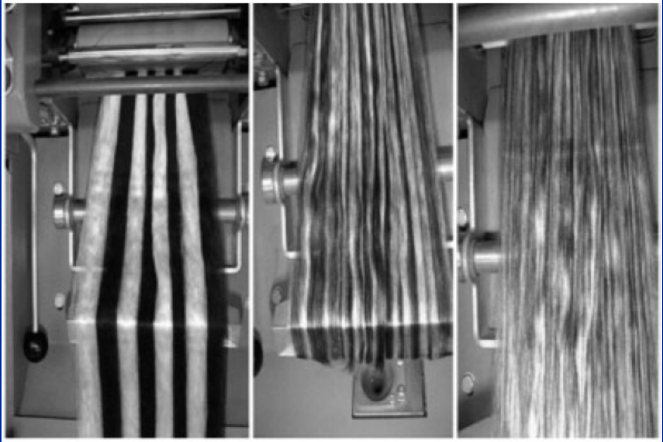


Single-zone drafting arrangement

PRINCIPLES OF DOUBLING:

This involves placing several slivers in parallel (usually 6 or 8) and roller drafting the combination using a draft equal to the number of juxtaposed slivers. Doubling serves two purposes. It enables the reduction of sliver irregularity and improves the blend or mix of the fibers.

Let six cards are 4.85, 4.95, 5.25, 5.42, 5.05, and 5.13 ktex with the cards being set to give a (calculated) count of 5 ktex. If these slivers are combined and attenuated by a draft of six, the resulting sliver count would be 5.1 ktex. *Due further doubling and drawing, the sliver weight will be closer to the set value. The doubling will be 6x6=36 times.* The basic principles of roller drafting concern short-term irregularities, autoleveling is used to minimize medium- and long-term irregularities.


First Passage Drawing | Second Passage Drawing | Third Passage Drawing

Objective of Drawing

- **Equalizing**

Relationship between the of ideal evenness and doubling, Drawing

Ideal unevenness

$$CV_O{}^2 = \frac{CV_i^2}{D} + \frac{10^2}{N_i} * \frac{V-1}{D}$$

Parallelizing

Blending

Dust removal

The drafting arrangement

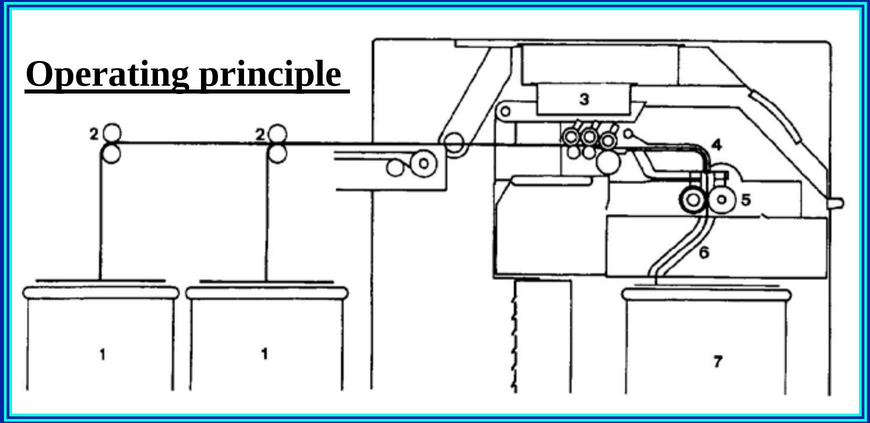
The drafting system must be:

Simple in construction, Stable in design , suitable for all raw materials

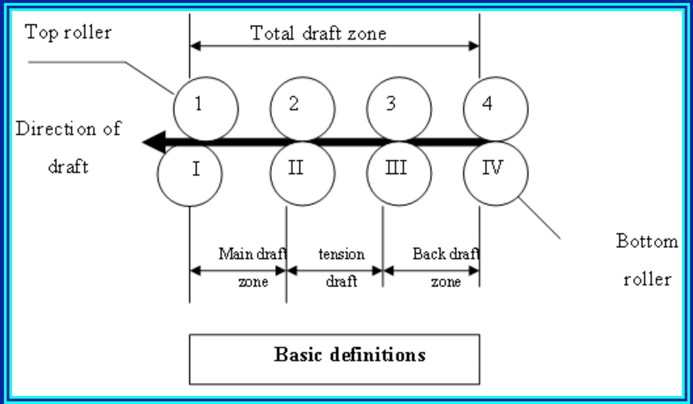
Optimal control over the movement of the fibers

High precision both of operation and adjustment

Rapid and simple adjustability of rollers



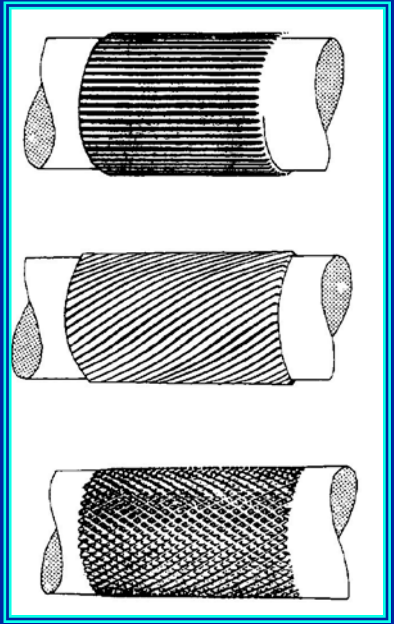
1) Can , 2)Feed roller, 3) Drafting system, 4) Guide tube, 5) Calenders, 6) Coiler and 7) Draw sliver



Elements of drafting arrangements

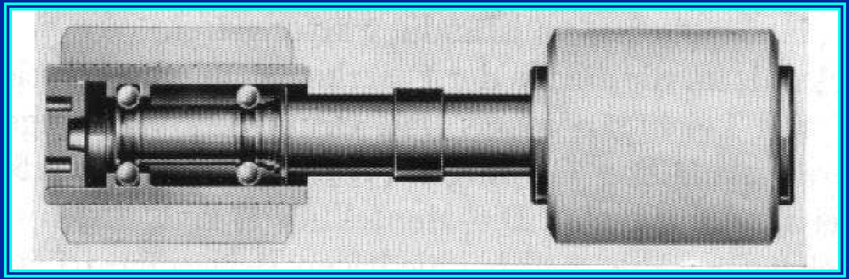
Bottom rollers

Fluting bottom rollers



- **Axial**
- **Spiral**
- **knurled rollers**
- **(used for aprons)**

Top rollers

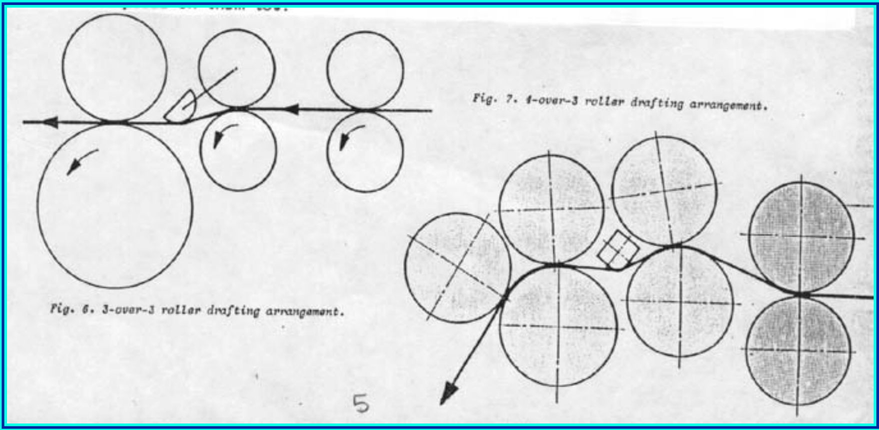


Top rollers are negative driven

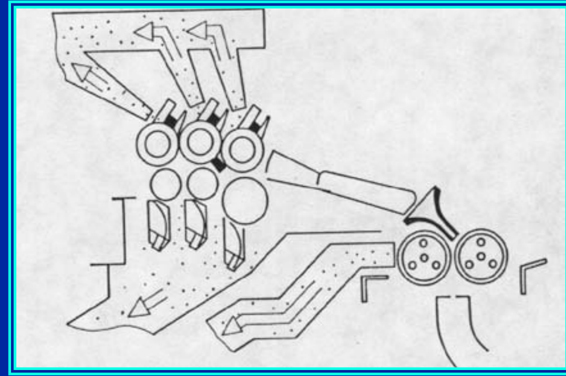
one-piece rollers or twin rollers

Ball bearing is used exclusively in the roller mounting thick coating forming the roller surface

Types of Drafting Systems



Suction system for the drafting arrangement



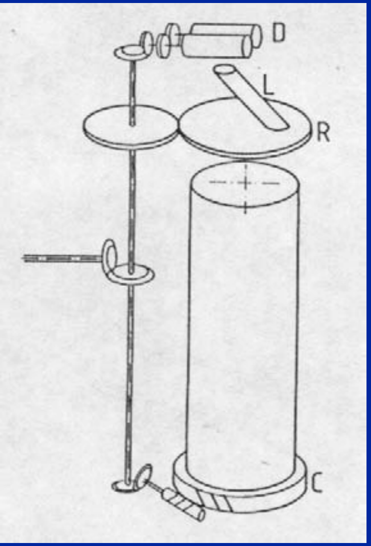
3 over 3 drafting arrangement with pressure bar

4 over 3 drafting arrangement with pressure bar

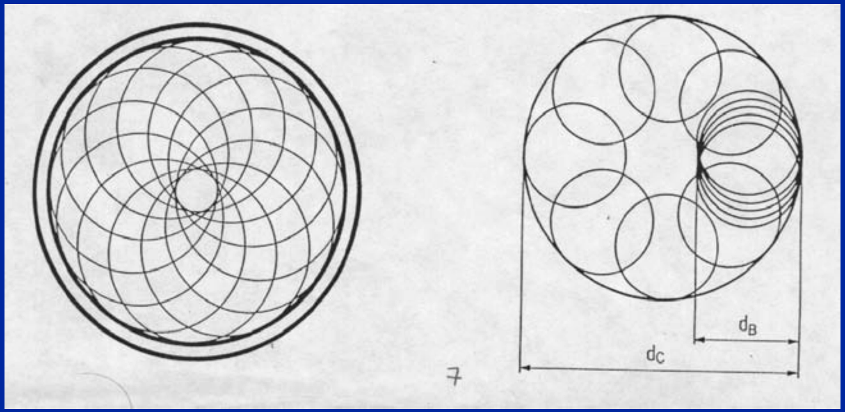
Laying the sliver in the can

Classical Laying down sliver in cans

Cycloid disposition of sliver is the most advantage method of filling can rotating plate R, with its guide passage L, draws the sliver away from the delivery cylinders D,
and continuously deposits
it in a circle.
A helical arrangement of the circle is produced within the can



Large and Small Coils

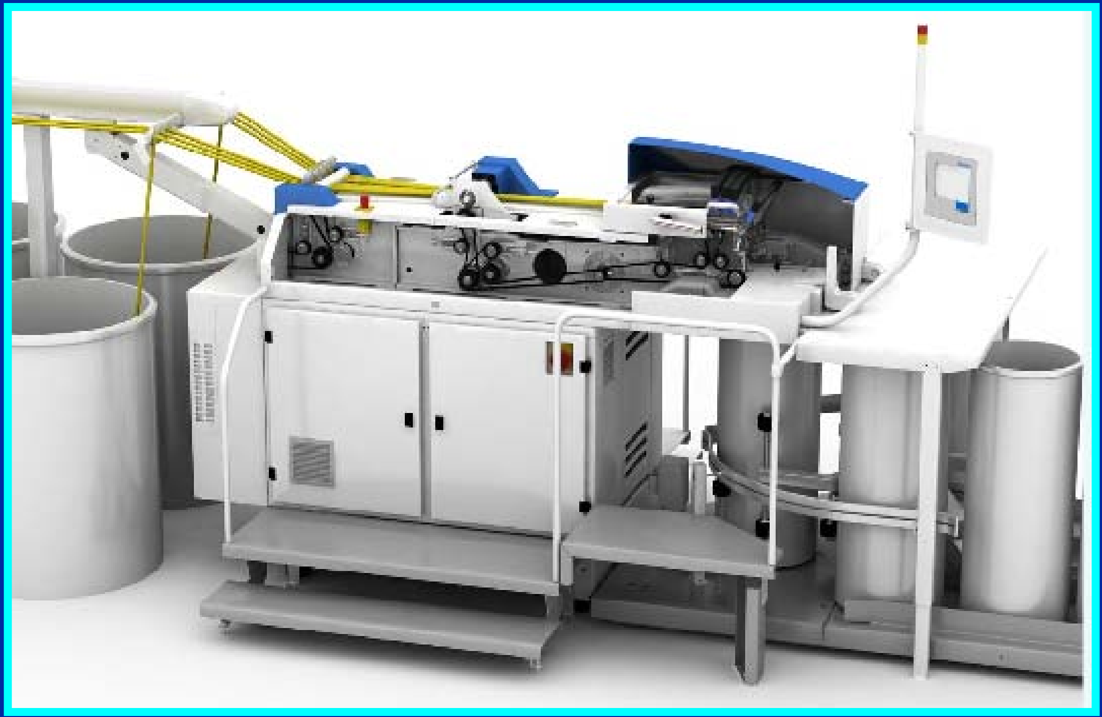


small coils, under center coiling or with large coils over center coiling"
for large coils is dc / dB = 1.45, and for small coils dc / dB = 2.5

Modern Drawing Frame

Main features of modern drawing frame

- Highly dynamic, digitally controlled, maintenance free direct drivers
- Comprehensive quality monitoring
    - Sliver weight
    - Sliver evenness
    - Thick places
    - Spectrogram
- Self optimizing adjustment of break draft
- Reliable sensors development
- Active lifting of top rollers during machine still stand
- Computer control with touch screen
- Infinitely variable setting of draft, break draft, sliver weight and delivery speed.



Adjustment of Drafting Zone Width

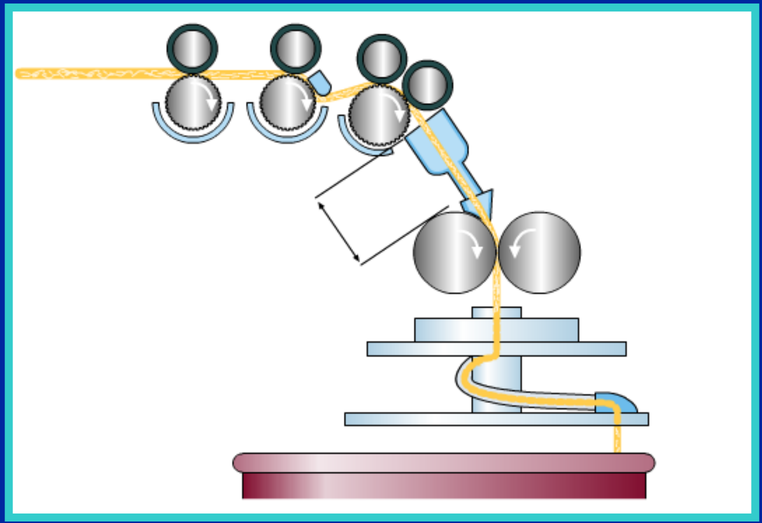
Quick adjustment of the drafting system width

The Drafting System is equipped with a quick action adjustment. Two scales show the drafting zone width.

Features of the Drafting System

New top roll carrier

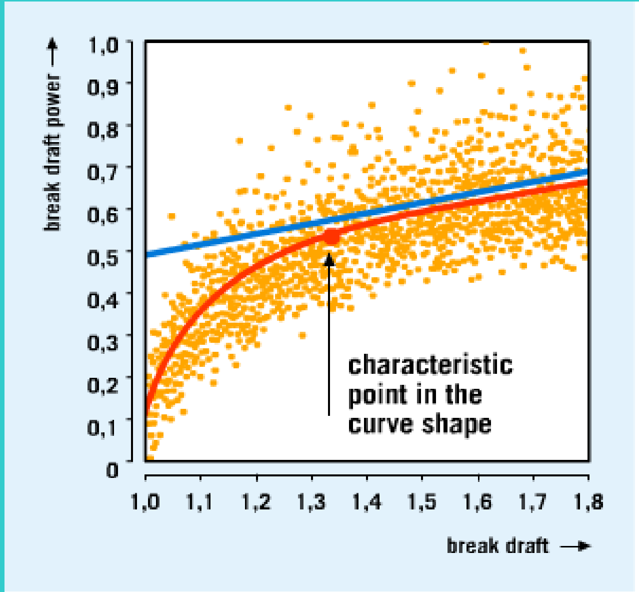
An automatic, self-adjustment wiring control is integrated in the top roll carrier



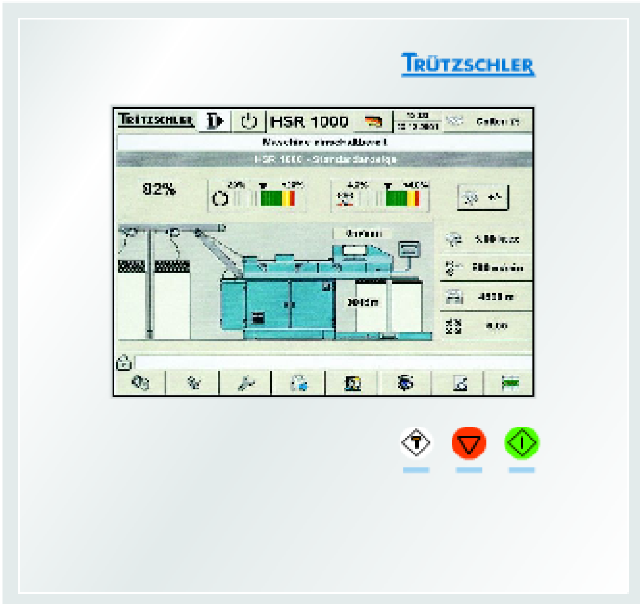
Reliable geometry of the drafting system for outstanding sliver evenness

The Principle of Self-Adjustment

AUTO DRAFT
Automatic ascertainment of the optimum break draft



The ideal point is calculated from the wealth of individual measurings.

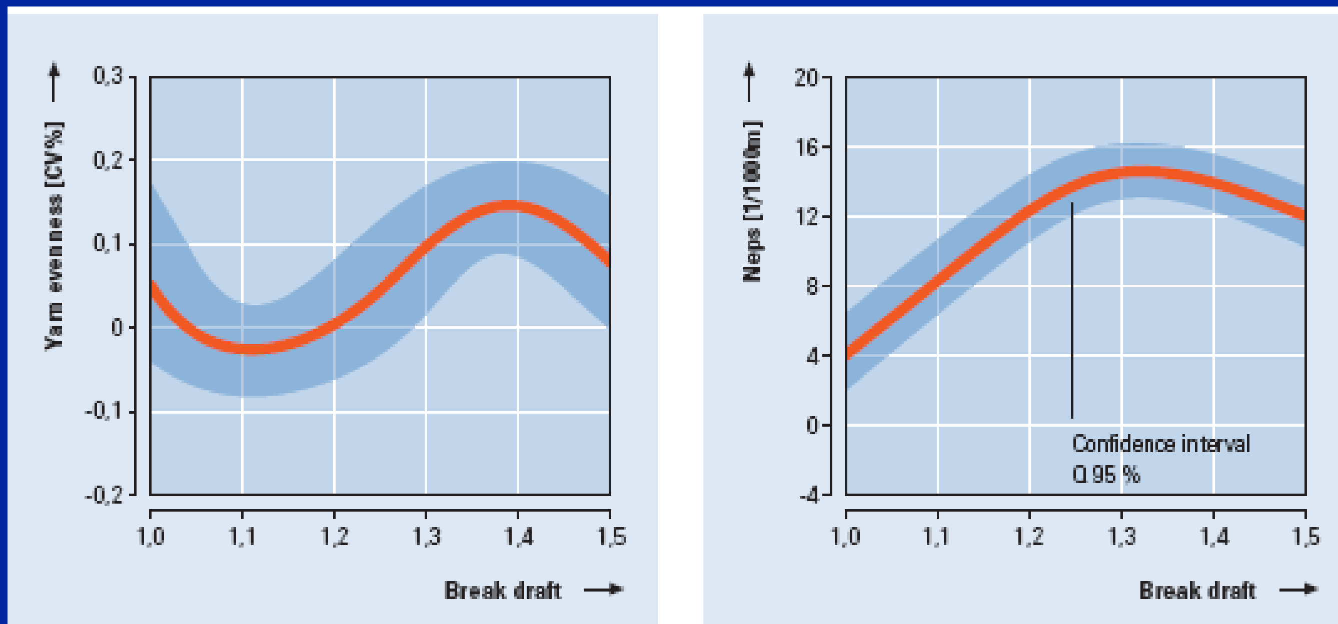


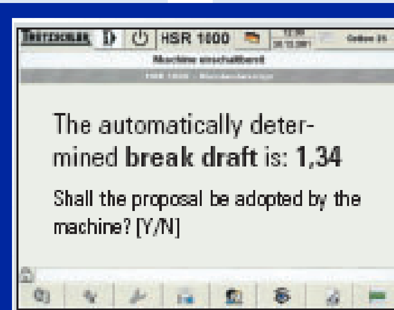
Start of the automatic ascertainment of the break draft

The AUTO DRAFT is a fully automatic self adjustment of the break draft. Thanks to servo motors used, the values of break draft are automatically changed and the power is measured. The optimum value is settled.

Auto Draft – Break Draft Effect

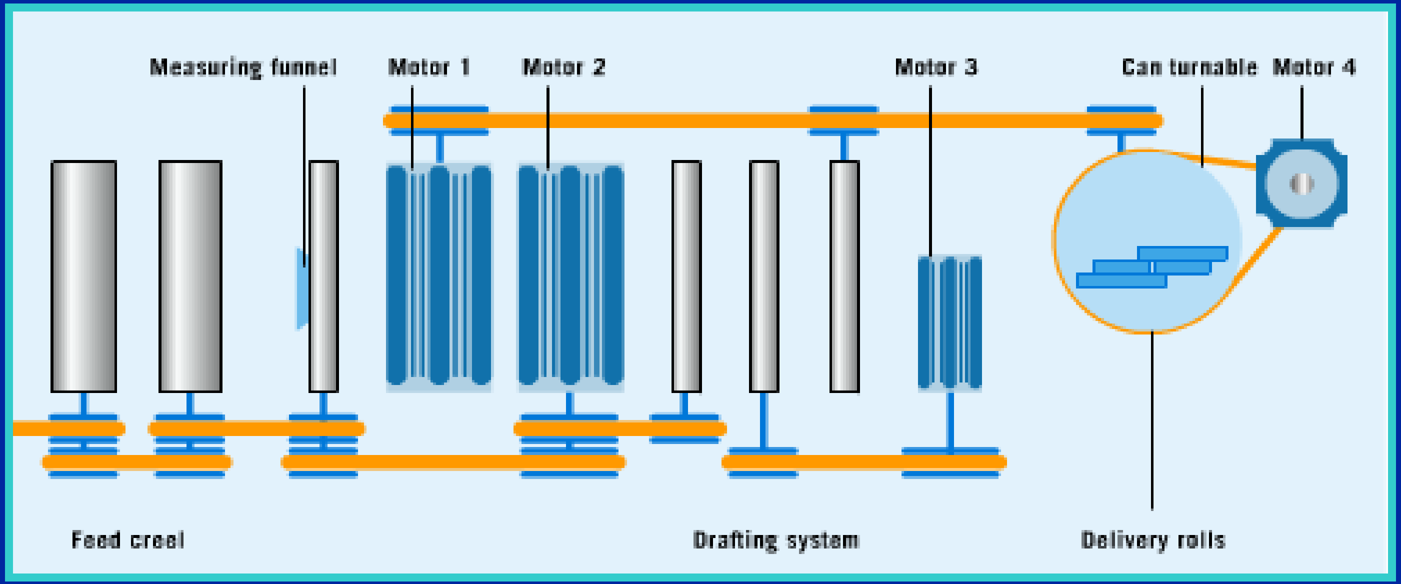
AUTO DRAFT
Automatic ascertainment of the optimum break draft





Drive Principle of AUTO DRAFT System

Digital servo motors are attached to the drafting cylinders



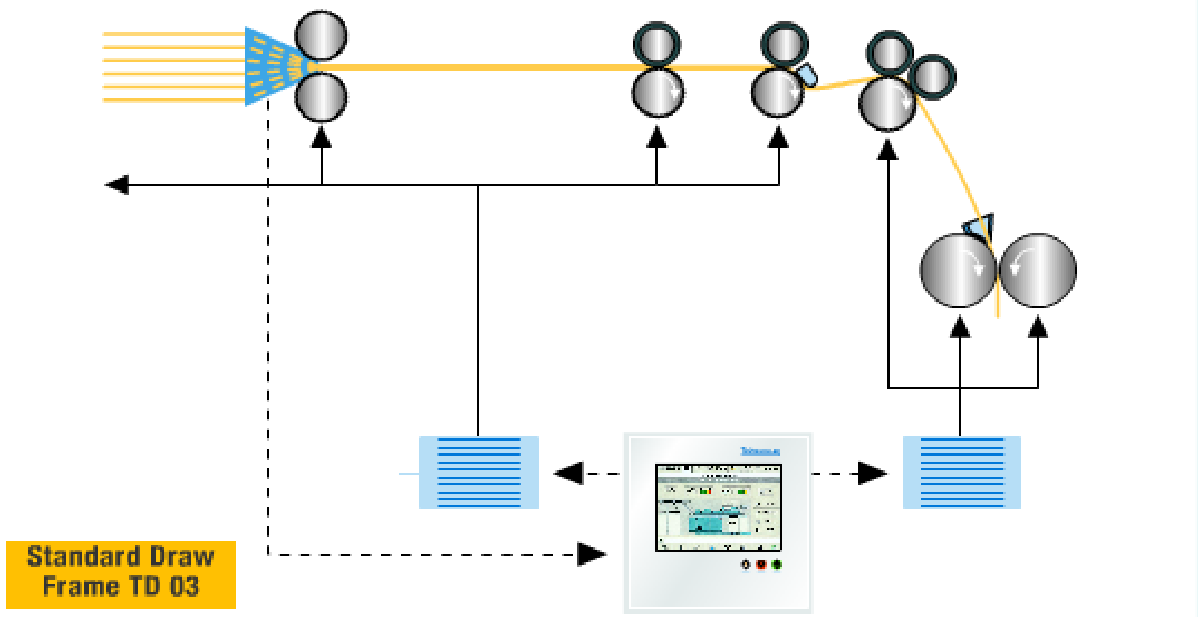
Auto draft

Digital controlled servo motors attached to drafting system drive the drafting cylinders in the shortest possible way via toothed belts. Computer control of these motors make it possible to dispense with differential gears and change wheels for draft and delivery.

Servo Draft System

SERVO DRAFT short-term leveller

The control of the draw frame processes the signal of the input sensor and drives the two digital servo motors.

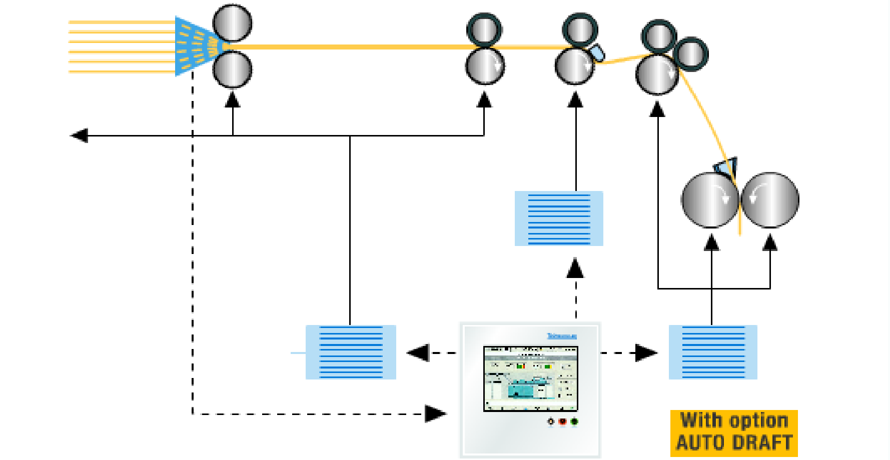


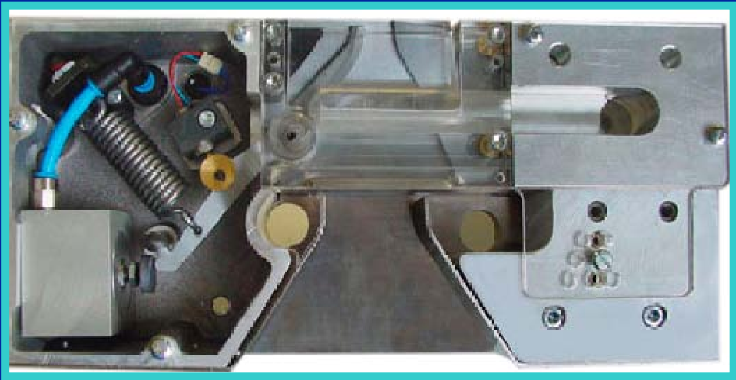
Automatic Control system

Principle of the measuring funnel

SERVO DRAFT short-term leveller

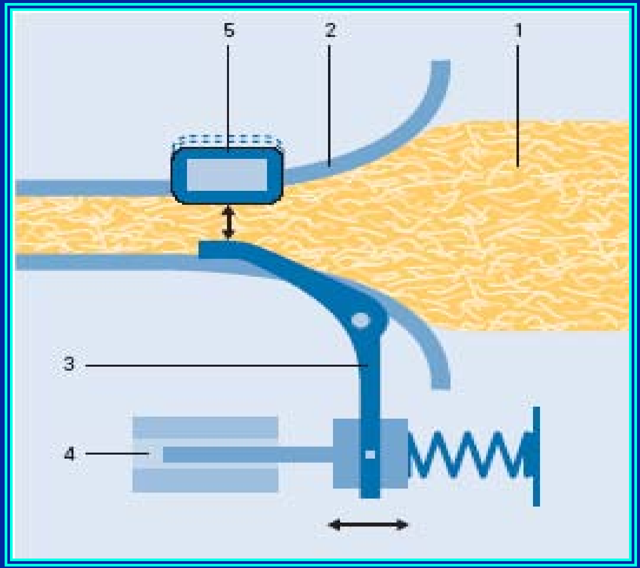
The control of the draw frame processes the signal of the input sensor and drives the three digital servo motors.





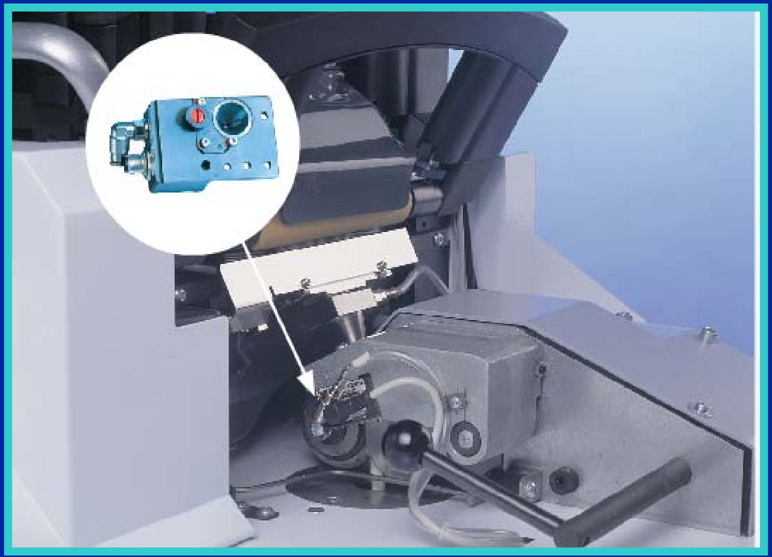
Sliver Focus for permanent Quality Monitoring

Sensor of sliver



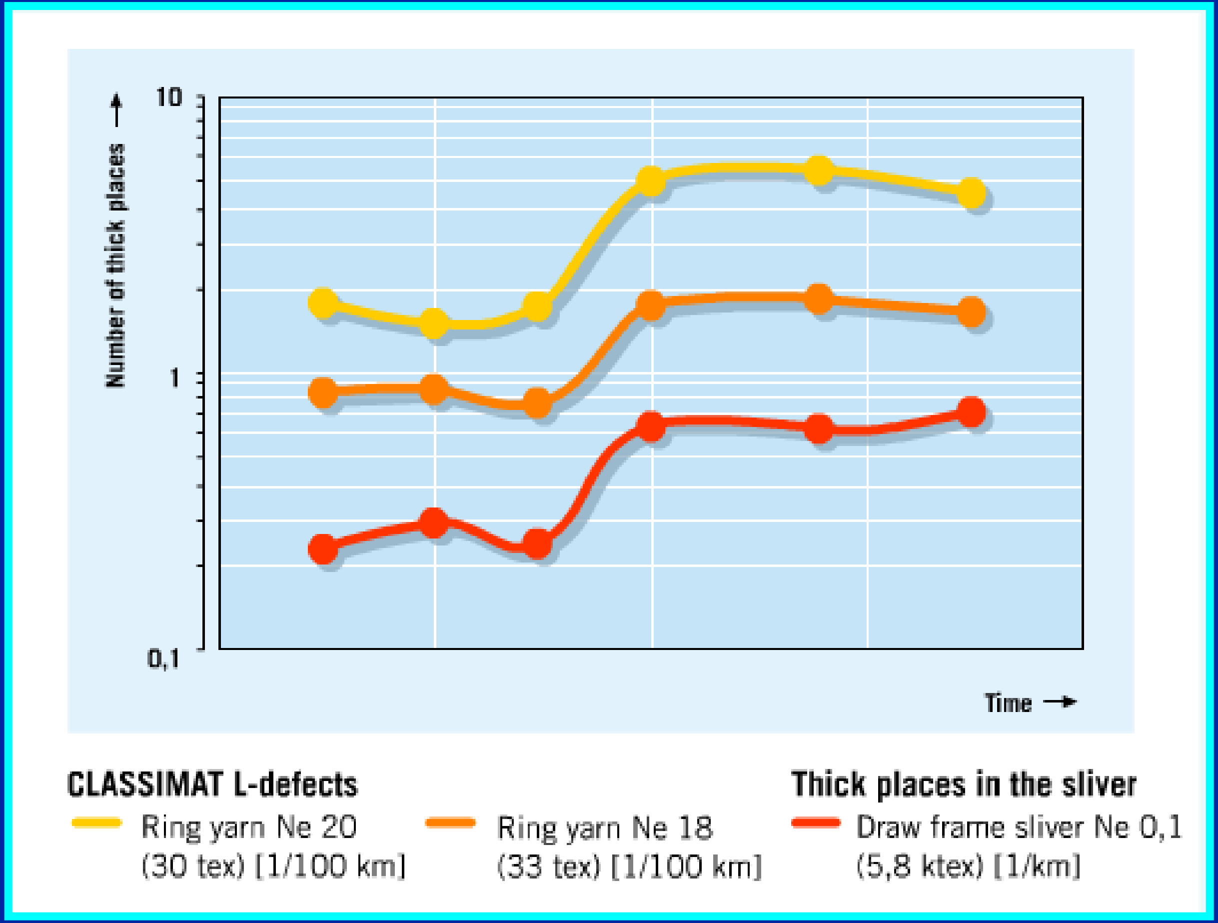
1 sliver
2 Measuring funnel
3 Spring-loaded measuring lever
4 Conversion of the mechanical into an electrical signal (displacement transducer
5 Here the sensor is adjusted to the sliver count

Continuous monitoring of sliver

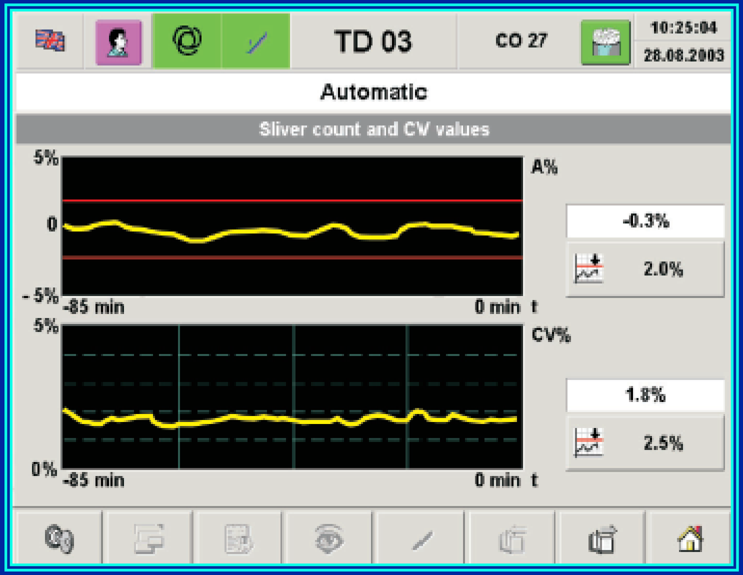


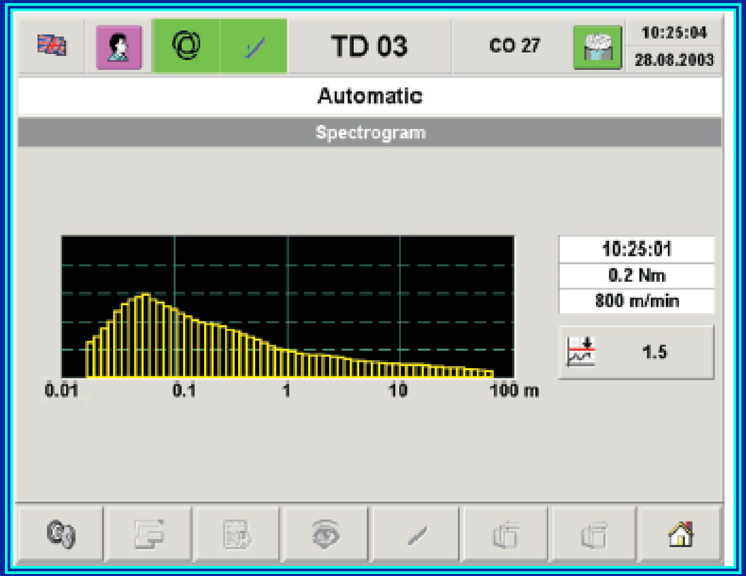
Yarn Imperfection

Correlation between thick places and long classimat defects in the yarn



Irregularity and Spectrum



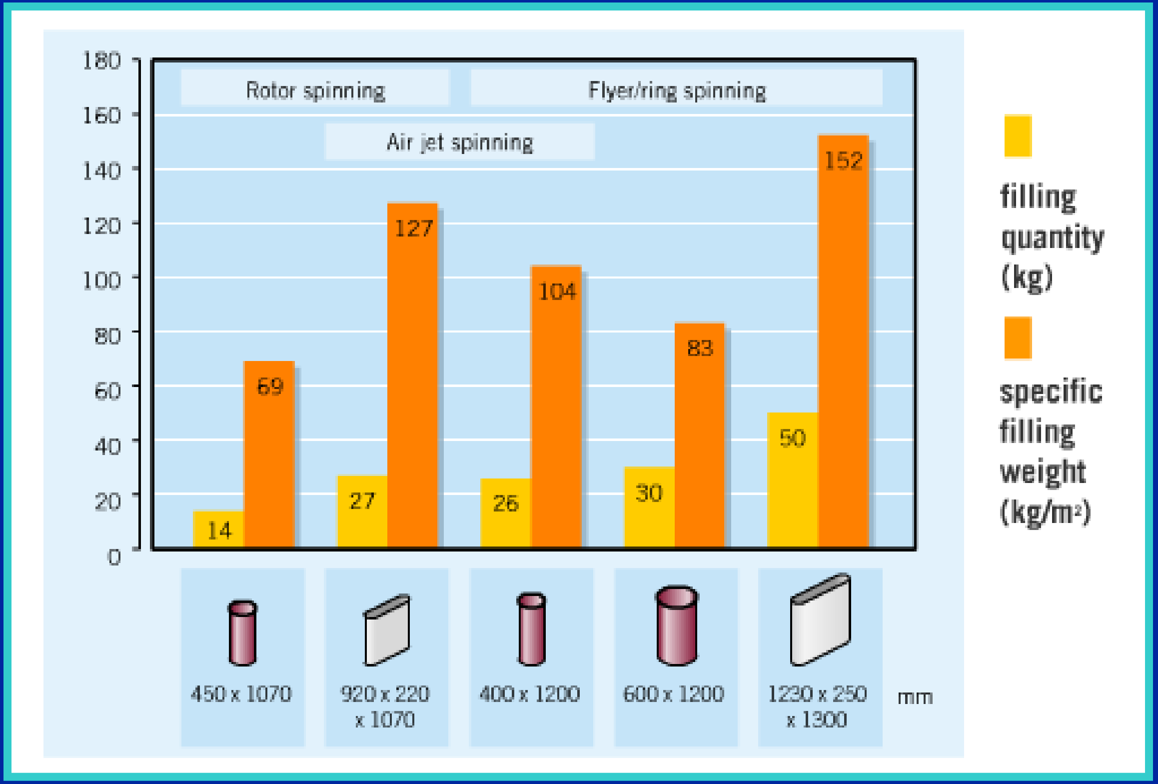


The results of the quality monitoring are displayed on screen of the draw control panel

The spectrogram is constantly monitored. The draw frame is stopped when individually defined quality limits are exceeded.

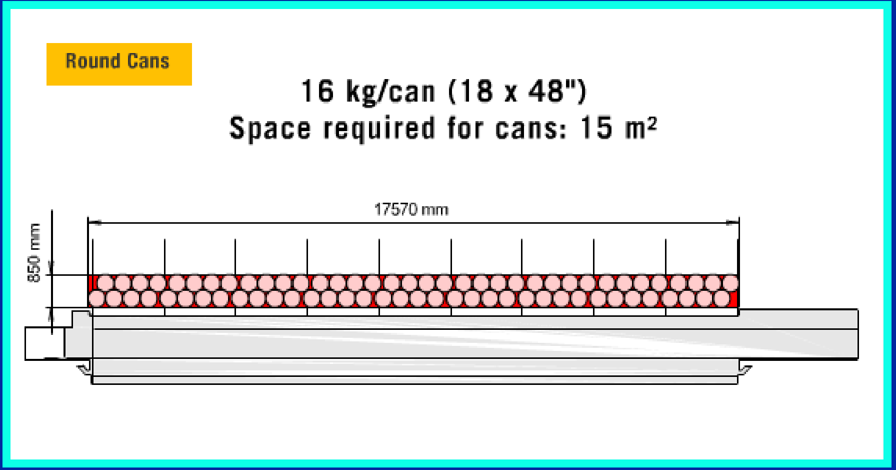
Rectangular Can Economy

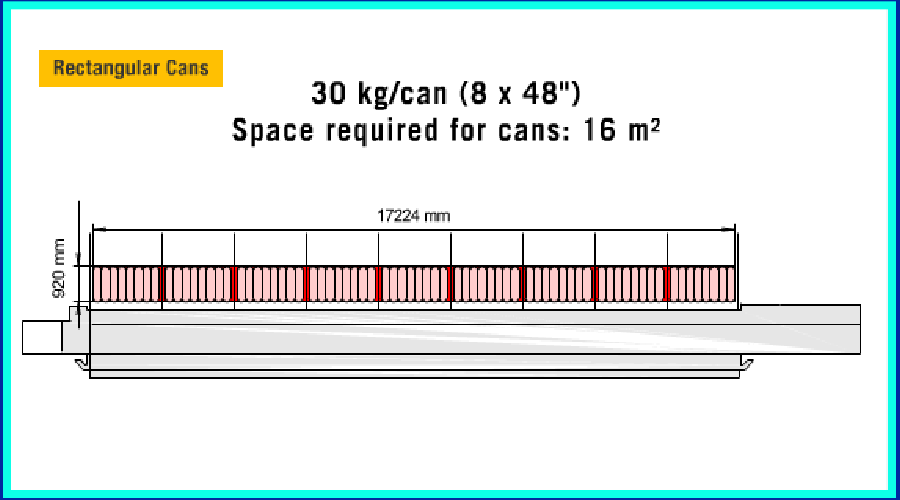
Rectangular Cans



Advantages of Rectangular Cans

More feed sliver for air-jet machines





Monitoring system and Control

The use of display means that the communication with the operator can mostly be made with the help of symbols or pictures which do not depend on language. The display is mounted pivoted in the immediate working area of the operator.

New operation and display concept

Integrated Draw Frame IDF

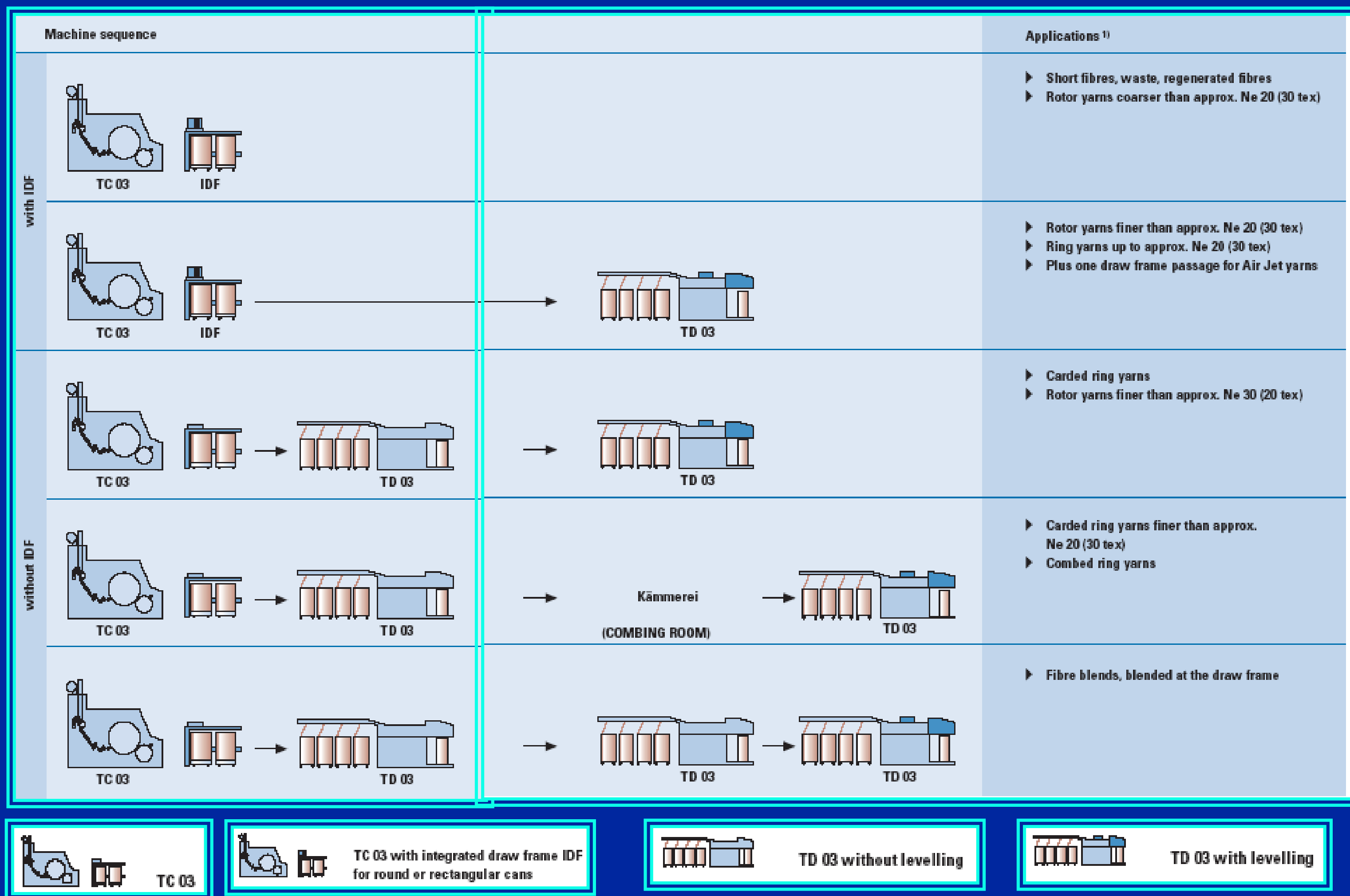
Process steps that do not exist do not produce any fault and do not cost any money.

Coupling of Card to draw frame i.e. one drawing passage is a good example for open-end spinning.

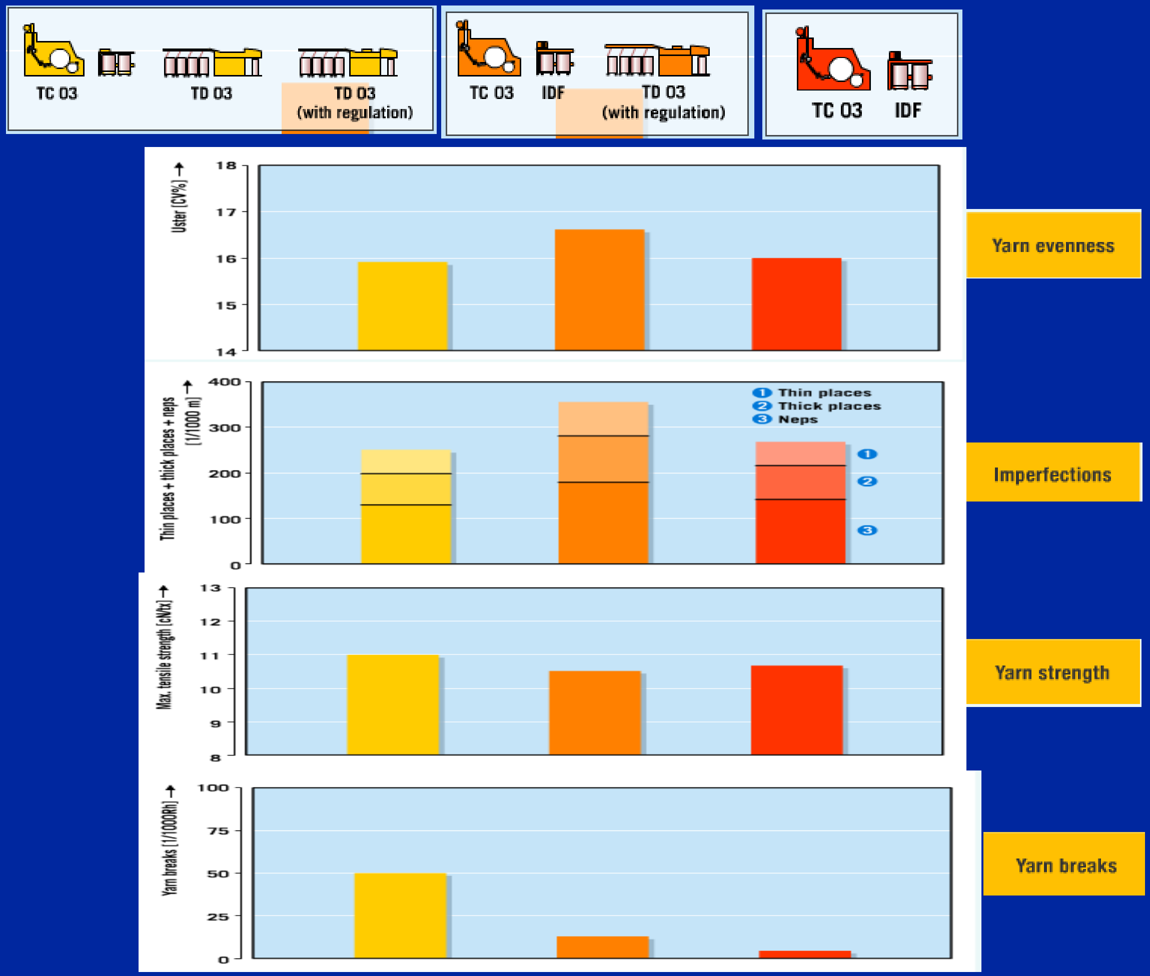
In combed spinning mill, process cutting with integrated draw frame is not useful.

Integrated Draw Frame IDF

Possible Installations with using Integrated Draw Frame IDF



Possible Installations with using Integrated Draw Frame IDF Selection of Correct Technology



Comparison of Yarn Quality

Economic Efficiency

Integration TC 03 with IDF result in:

•Less material in process, means less capital tie-up.

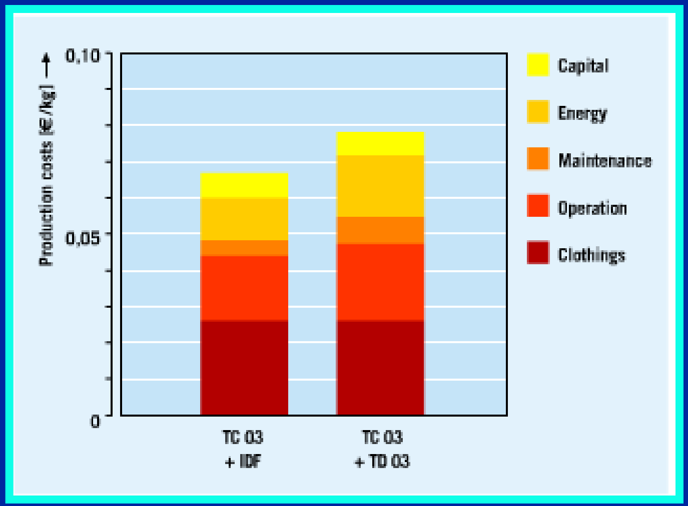
•Shorter throughput time.

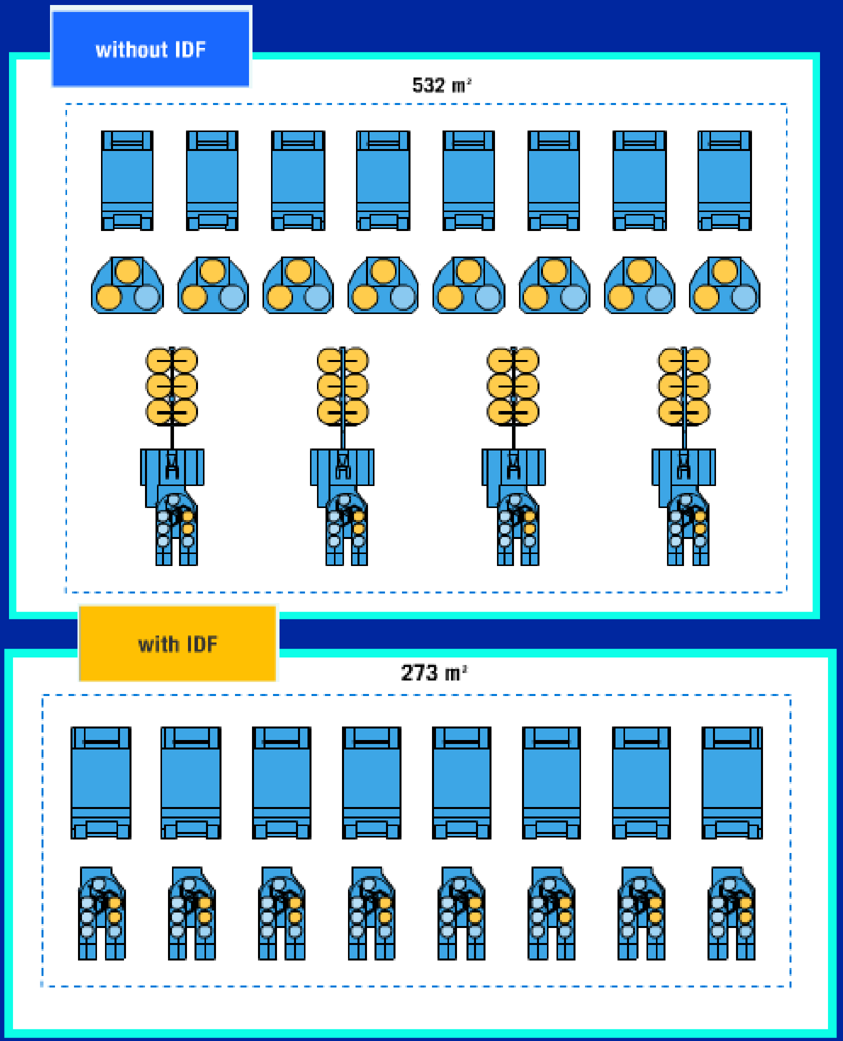
•Reduce operating work.

•Elimination of one error source (can confusion).

•Lower space requirement.

•Fewer cans.

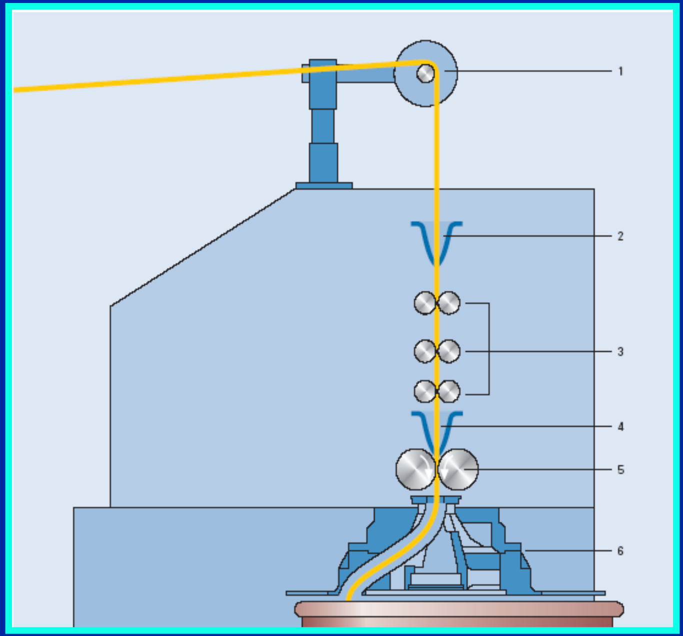




Concept of Auto-leveler Draw frame

1. Input measuring funnel
2. 3 over 3 drafting system
3. Output measuring funnel (sensor)
4. Delivery rolls
5. Deflection roller
6. Sliver coiling with three dimensionally curved tube, smoothly coils the sliver in the can

The IDF drafting system concept correspond to that of an auto leveller draw frame



Maintenance free servo drivers,

High leveling dynamics,

Draft up to 500 m/min.

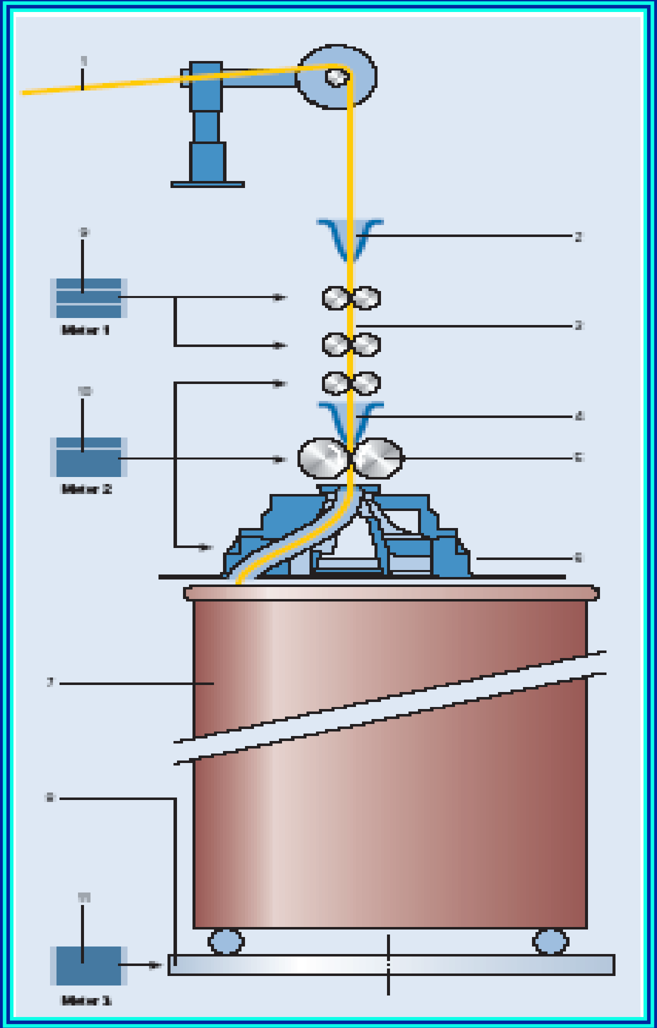
Sensors in feed and delivery areas

Permanent monitoring the sliver quality.

Details of Digital Servo motor Drive system

The integrated draw frame is driven by three maintenance free servo motors:

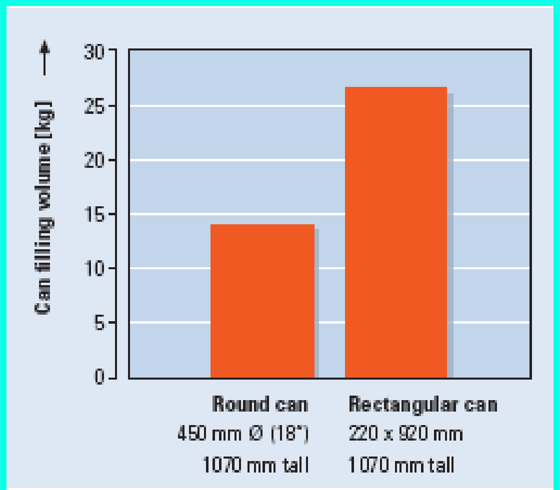
- Motor 1 drives back and middle cylinders of draft system
- Motor 2 , the main motor drives delivery cylinder and sliver coiling plate.
- Motor 3 drives the rotary can.
- No need for mechanical driving system, gears, chains,…
- Most important settings can be made through the 3 motors, without exchanging gears.
- Pressing a botton for change draft, sliver count, delivery speed or the geometry of coiling.
- Getting exact speeds and synchronization.
- All drives automatically adapted themselves to delivery speed.
- System monitoring.



7 Can, 8 rotary can plate, 9 leveling motor, 10 Main motor sets delivery speed, 11 Coiling geometry can be optimized .

Automatic Round and Rectangular Can Changing

Rectangular cans are a good solution for OE spinning Machines, where cans are directly used for feeding.
Cans of small diameters for OE of 400 to 450 mm. Cans with diameter of 600 or 1000mm are for feeding a subsequence draw frame.
Can heights can be between 900 and 1500 mm. The sliver is automatically separated when the can is changed.



The capacity of the rectangular can is nearly double

Automatic can changer for round cans

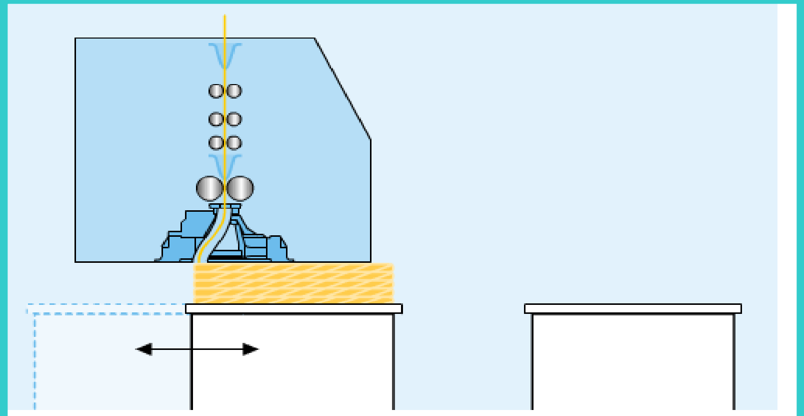
Automatic can changer for rectangular cans

Can Changing During Production

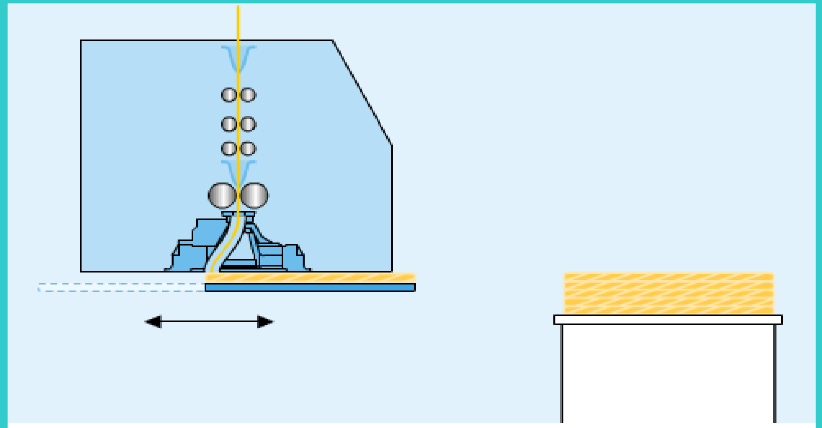
Rectangular can changer at draw frames have existed for quite some time. The draw frame is stopped for can changing.

This is not possible when it is combined with card.

During the changing procedure the machine coils the sliver on an intermediate base inserted between sliver coiling plate and can. When the empty has been put in the filling position, the intermediate base swings back and transfers the coiled sliver to the lifting bottom of the can. The intermediate base swung in and out very rapidly without interfering with the can coiling.

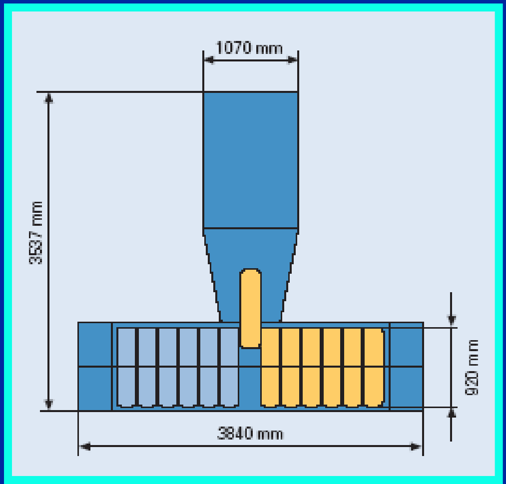


The can is ful. In the can magazine an empty can is ready for delivery.

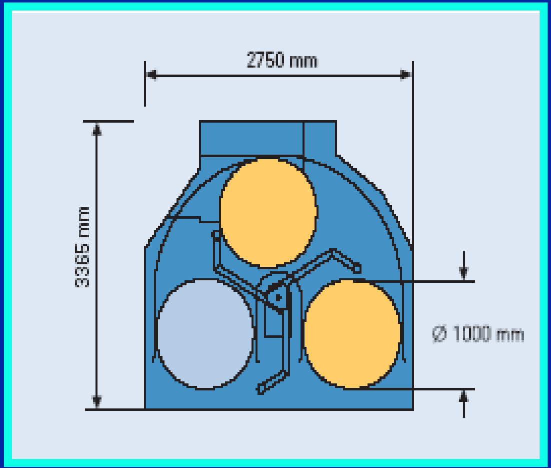


The full can was supplied to the can magazine. The sliver is coiled on an intermediate bottom.

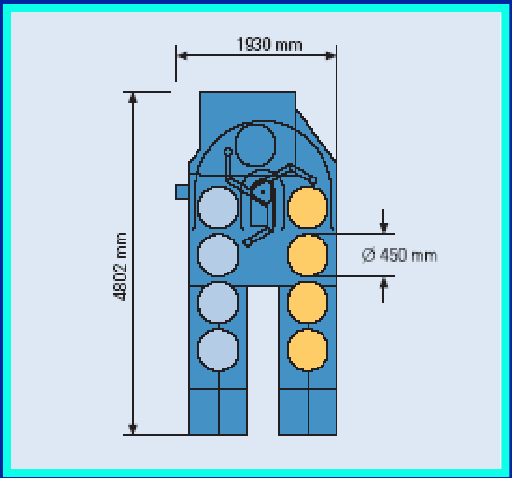
Can Changer for Small, Big Diameters and Rectangular Cans



Can changer for rectangular cans with can buffer for empty and full cans



Can changer for cans with 1000 mm (40") diameter



Can changer for cans with 450 mm (18") diameter

THE 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 by about 1 US$/Kg

Tasks of combing:
•Elimination of precisely pre-determined quantity of short
•fibers
•Elimination of the remaining impurities
•Elimination of a large proportion of the neps
•Formation of a sliver having maximum possible evenness
•Producing of more straight and parallel fibers

Elimination of short fibers improves mainly the staple length Micronaire value of combed sliver is slightly higher than that of feedstock

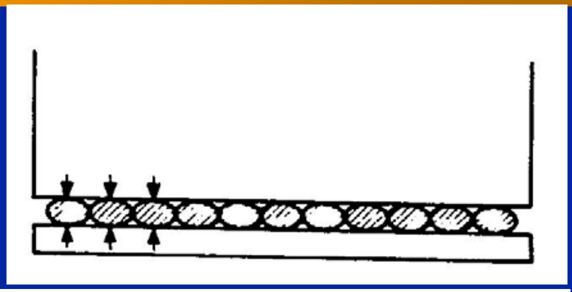
Types of applications:

•*Long staple combing:*
High quality cotton, containing a low proportion of short fibers

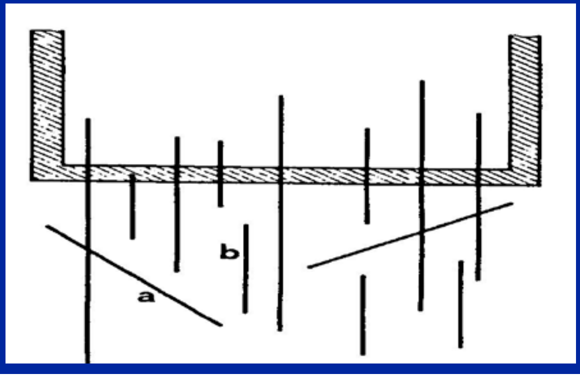
•*Medium-staple combing:*
•medium cotton qualities, spun to medium (to fine) yarns of good quality at economic production costs.

•*Short (to medium) staple combing mills:*
• Upgrading quality of cotton, extracting low level noil level (6 – 14%)

PREPERATION OF STOCK FOR COMBING

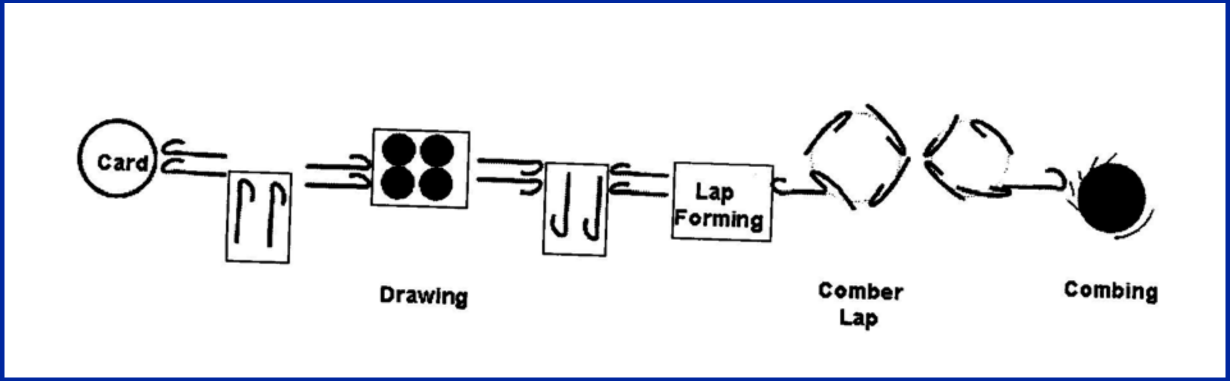


The raw material delivered by the card is unsuitable for combing; bad fiber arrangement; nipping would occur only on the high points
degree of evenness is therefore required Long fibers may be combed out; this present Unnecessarily loss of good fibers

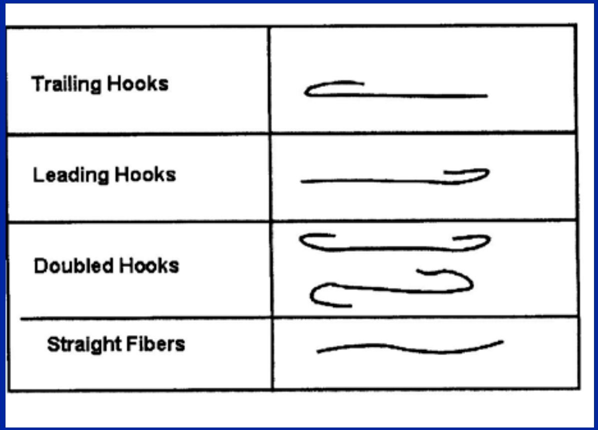


Over 50% of fibers in card sliver have trailing hooks; 10% of leading type, 10% double hooks

- **Majority of hooks entering the combing process should be leading type**
- **positioning of two processing stages (drawing and lap forming)**



Hooks reversal during processing



Methods for Preparation for Combing I

Conventional (Lap Doubling) method:

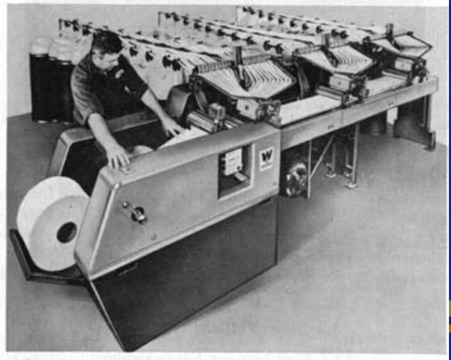
Sliver Lap (D=16…24, V=1.1 ….2) and Ribbon Lap (D=6, V=6)

Sliver lap Machine

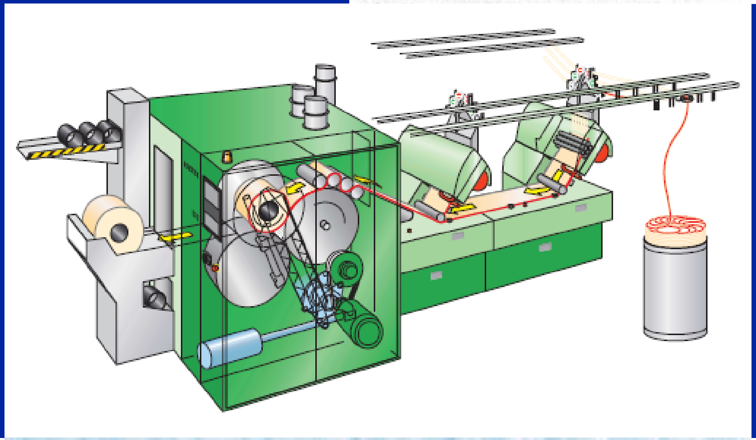
Ribbon lap machine

- 16 to 32 are fed to a sliver lap machine, of three pairs of drafting rolls followed by two pairs of calender rolls
- Lap pf 50 to 70 g/m, width of 230 to 300 mm and diameter of 500mm and weight of to 27Kg. Draft ratio commonly is 1.5 to 2.5. Draft ratio commonly is 1.5 to 2.5. Laps from the sliver lap machine are taken to the ribbon lap machine thin sheets from the heads are led down over a curved plate, which turns at a right angles, inverts them and superimpose one upon the others

Methods for Preparation for Combing II



(Sliver Doubling): e.g. Super lap from Whitin
About 20 drawing slivers are fed to a vertical 2/3 daft system, and drafted 3 to 5x.
The laps are super imposed (width of 293 mm) through a pair of calander rolls, the batt is compressed and the lap is formed

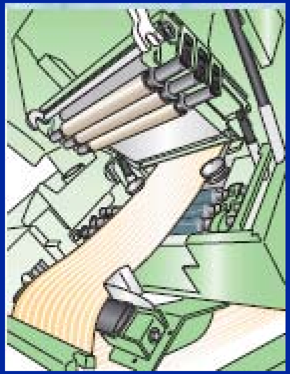


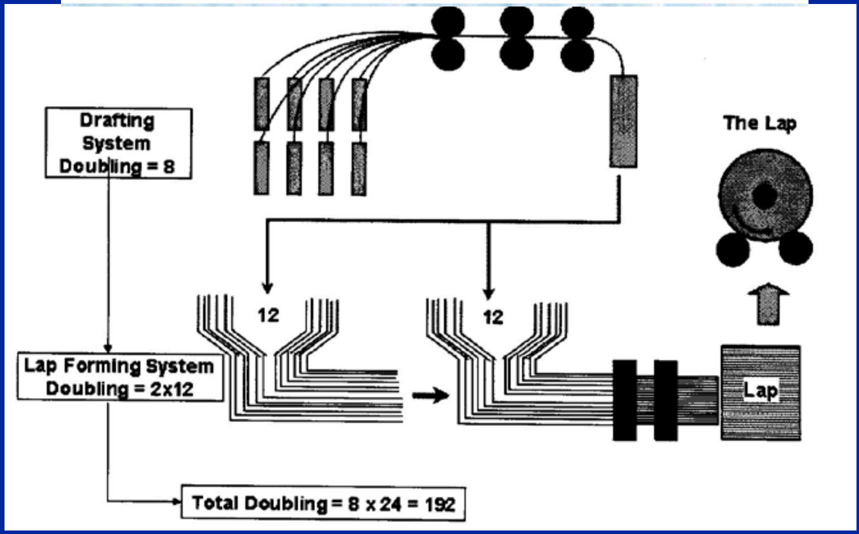
Unilap from Rieter (drawing/lap)

- **two steps: a standard drawing process in which a number of card slivers (typically 20 – 24) are drawn Together to form a drawn sheet lap weight 50 – 70 g/m delivery speed up to 100 m/min production rate is up 360 kg/h.**

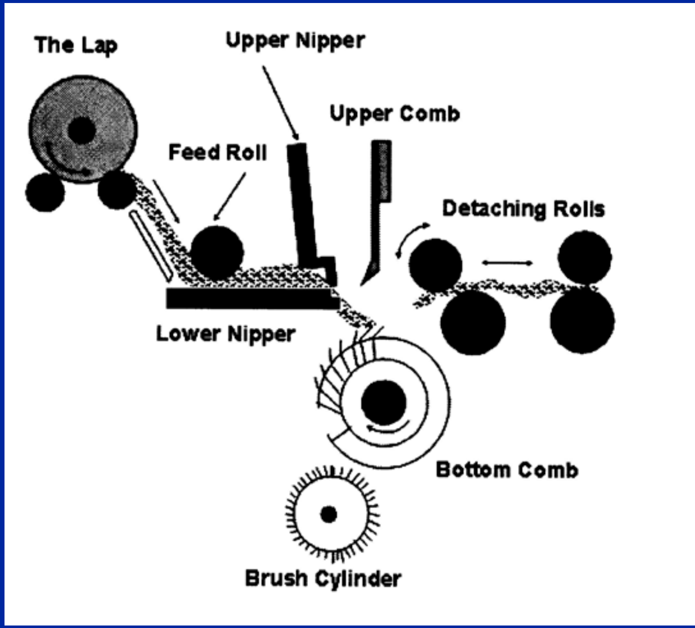
Laps of up to 25 Kg weight, 250-300 mm width

- **The Unilap system is designed**
- **to achieve fully automatic doffing**
- **and transportation of laps to the combing.**





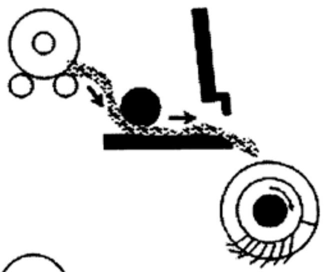
The Combing Machine



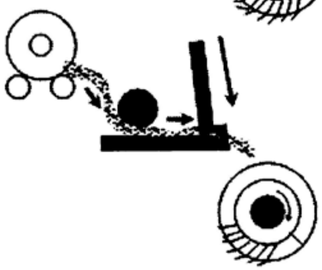
Parts ob the combing Machine

The Combing Cycle

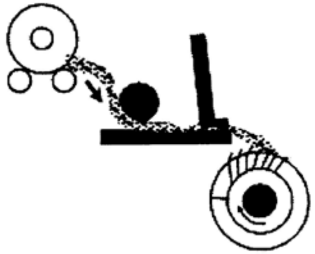
Step 1: Feeding
The feed roller feeds the lap forward (a small distance 4-7 mm). The nippers are open



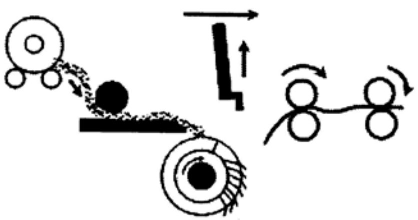
Step 2: Nipping
The upper nipper is lowered onto the cushion plate so that fibers are clamped between them



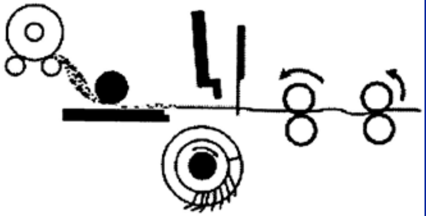
Step 3: Bottom Combing Action [Rotary Combing]
The bottom circular comb is now acting on the nipped fibers to remove all fibers or wastes that are not nipped



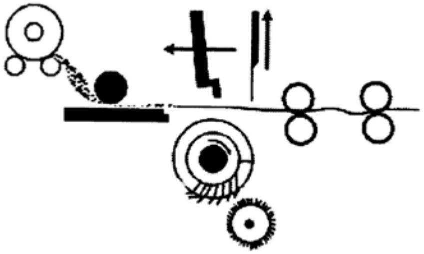
Step 4: Nippers Forward/Web Return
The nippers open again and move towards the detaching rollers. Meanwhile, the detaching rollers have returned part of the previously drawn off material by means of a reverse rotation, so that a portion of the web is projecting from the back of the detaching device.



Step 5: Piecing
During the forward movement of the nippers, the projecting fiber fringe is placed upon the returned material for piecing the two ends.



Step 6: Detaching/Top Combing
The detaching rollers begin to rotate forward drawing the fiber material held by the feed roller. Before the start of the detaching action, the top comb has moved to act with its row of needles onto the fiber fringe. As the fibers are pulled through the needles of the top comb, the trailing part of the fringe which was not handled by the bottom comb is combed.



Step 7: Noil Removal
This is achieved using a rotating brush

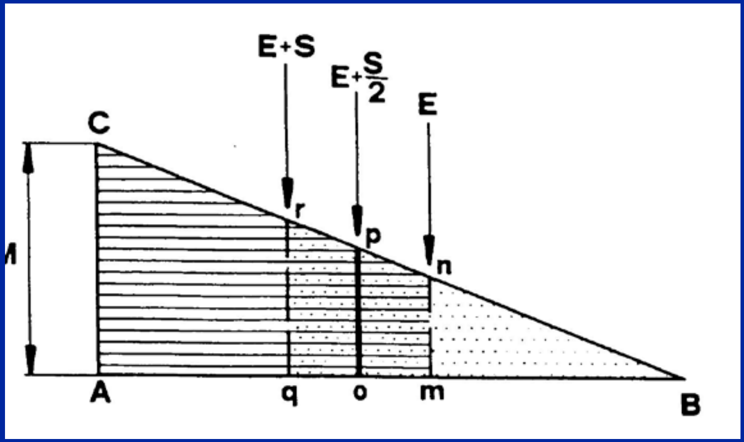
The noil theory of Gegauff

Two types of feeding are used in combing process:

Concurrent feed: (forward feed); Feeding during detaching

Counter-feed: (backward feed).; Feeding after detaching

Combing with concurrent feed

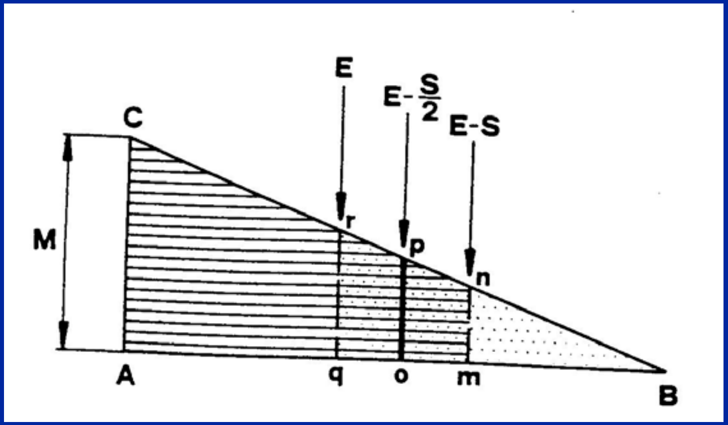


$$p\% = [(oBp)/(ABC)]*100$$

$$= [(op)^2/(AC)^2]*100$$

$$= \{[E-(S/2)]^2/M^2\}*100$$

Combing out with counter feed

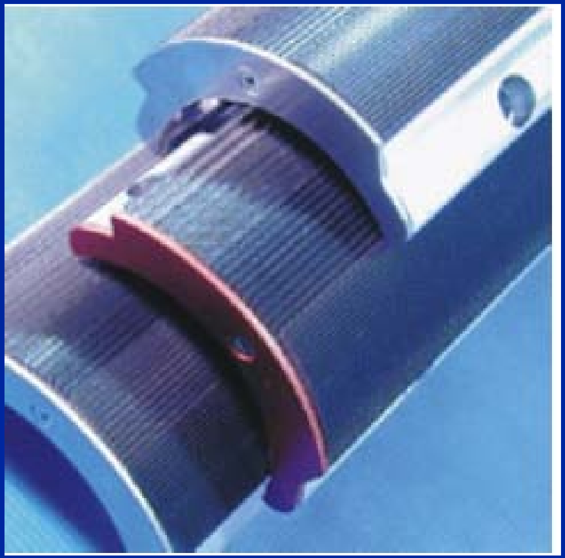


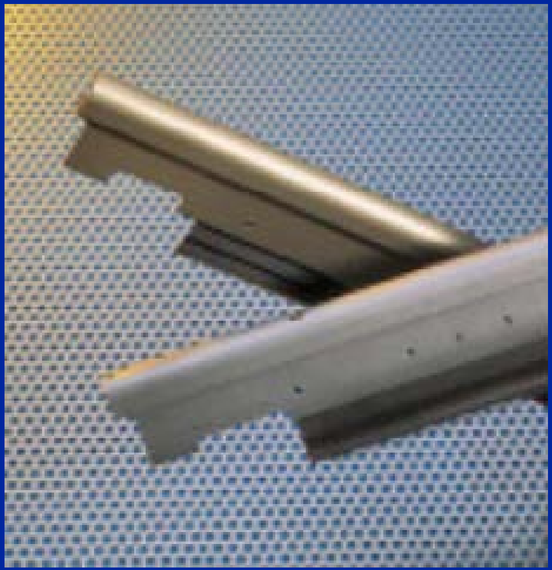
$$p\% = [(oBp)/(ABC)]*100 =$$

$$[(op)^2/(AC)^2]*100$$

$$= \{[E+(S/2)]^2/M^2\}*100$$

Different types of circular combs





Circular comb:

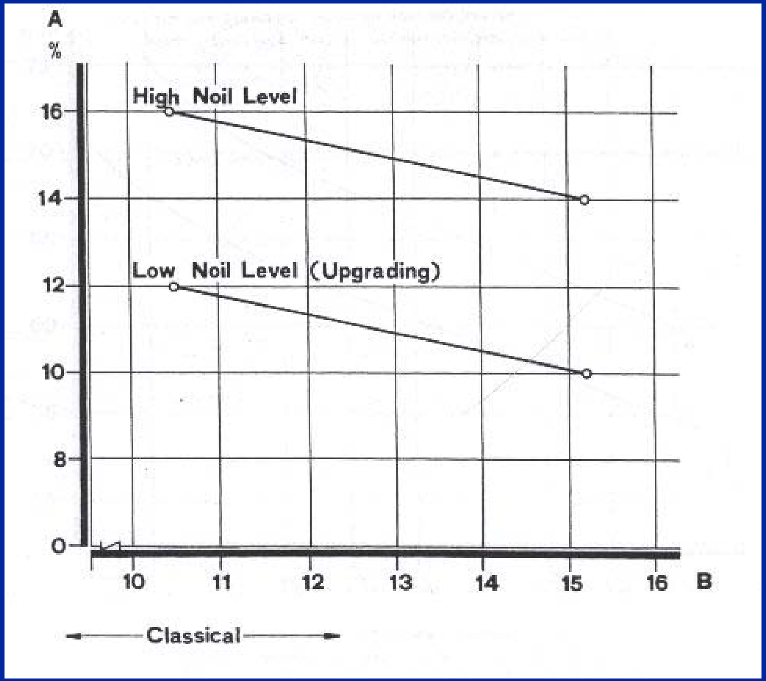
Top comb 21, 23, 26, 28, 30, 32
needles per centimeter

THE TECHNOLOGY OF COMBING

Parameters influencing the combing operation:

Raw material: Fiber type; fiber length; uniformity of fiber length (cv); fiber stiffness; moisture content.

Material preparation: Parallelization of fibers in sheet; sheet thickness; sheet evenness; orientation of hooks



Factors associated with machine:

Condition of machine, Machine setting, Ambient conditions

Influence of feed stock on combing:

Parallelization of fibers in the sheet:

Lake of longitudinal orientation, noil quantity decreases linearly with increasing Parallelization more noil isnot automatically associated with better yarn quality. The correct goal is always a predetermined waste elimination level

Sheet thickness:

Optimal sheet fineness now normally lies between 55 and 75 ktex

THE TECHNOLOGY OF COMBING

Evenness of the lap sheet:

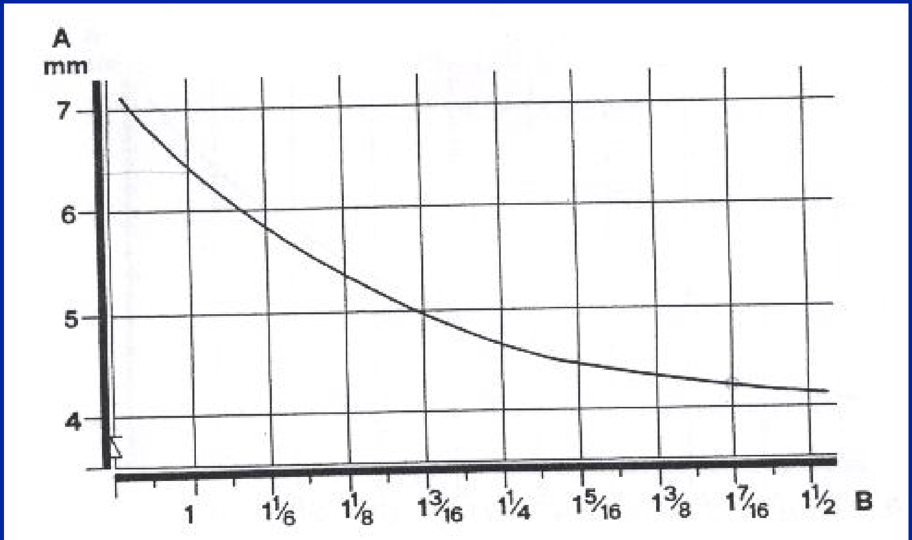
Evening of the lap is of considerable significance "better clamping".
High degree of evenness is due to higher doubling

The disposition of the hooks:

Fibers should be presented to the comber so that leading hooks , wrong direction, markedly increase the number of neps

Quantity and form of fiber hooks depend mainly upon the stiffness. Fine and long fibers, will always exhibit more and longer hooks (horseshoe shape) than short fibers, coarse fibers (hokey stick form).

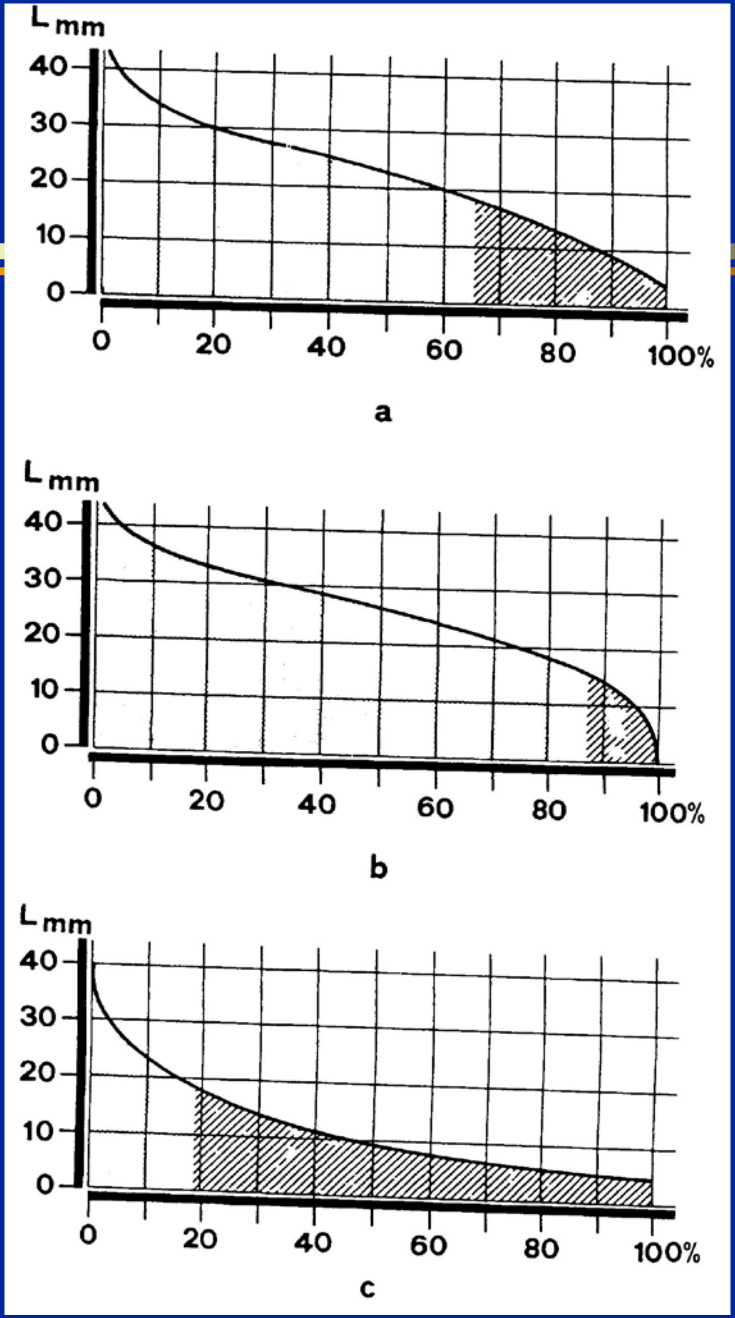
Role of fiber hooks in spinning process becomes more significant as fibers become finer.



Typical values for the fineness of the feed sheet. A

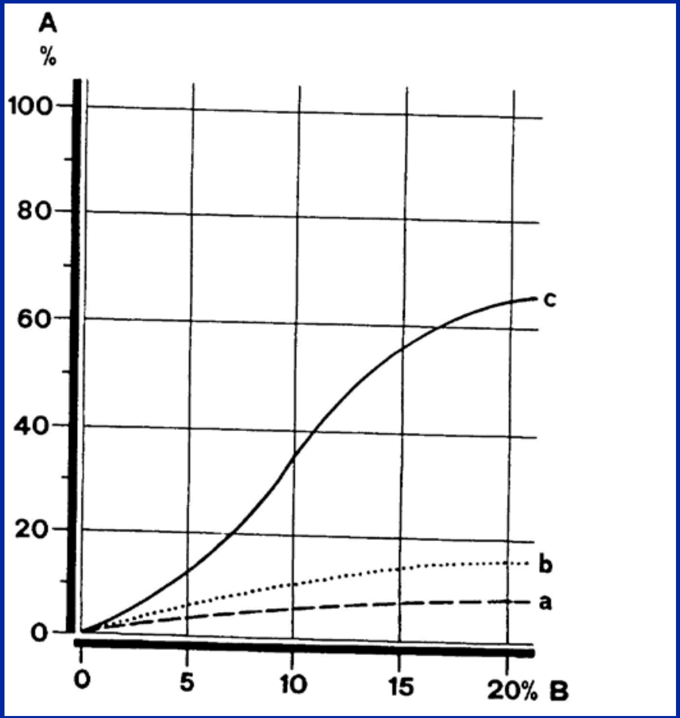
Influence of combing operation on quality

Following is the classification of quality of combed yarns:
Semi-combed (upgrading to higher grade) with noil percentage of 5 -10% (-12%)
Normally combed, with a noil percentage between 10 and 20 %.
Super combed, with noil percentage over 20%.



Staple diagram a) before Combing; b) after combing; c) noil

Influence of combing operation on quality



Dependence of various quality parameters n noil. A, improvement of yarn quality %; B, Noil in %)

a**) yarn strength, b) yarn evenness;) yarn** Imperfections.

THE ROVING FRAME

The roving frame is a necessary evil

The draft needed 300 to 500

•draw frame cans represent the worst mode of transport

•The roving frame itself is a complicated, liable to faults, causes defects

•Automation of the machine is very difficult

•*Demands placed upon modern roving frame:*

•Design of simpler machines, less liable to faults; Increasing in spindle rotation rates; Large packages;

•Automation of machine and of package transport

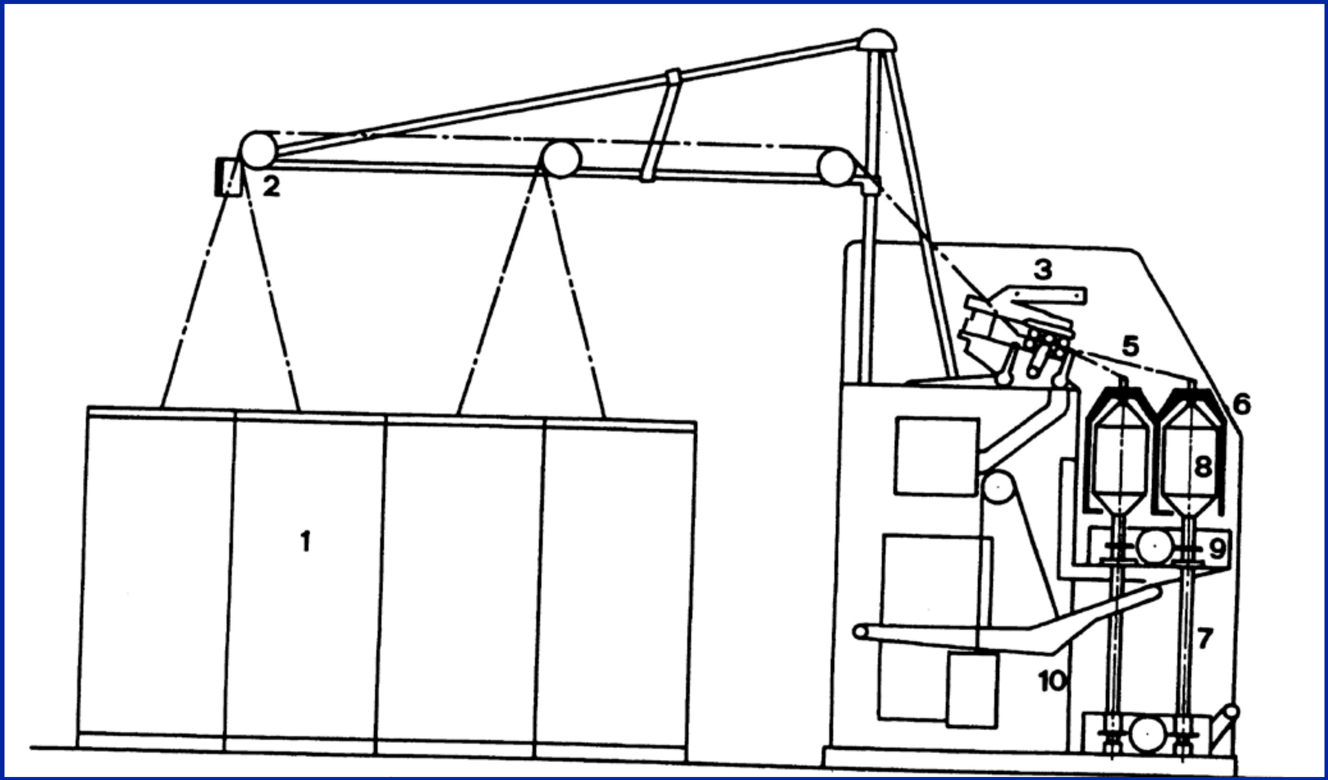
• *Tasks of the roving frame:*

•Attenuation the sliver to a fine strand

•A protective twist must be inserted, that the roving can be wound on a package transported

•Roving winding makes the roving frame relatively complex winding requires in addition to the spindle and flyer, a cone drive transmission (or variable gear), a differential gear and a builder motion.

Description of functions



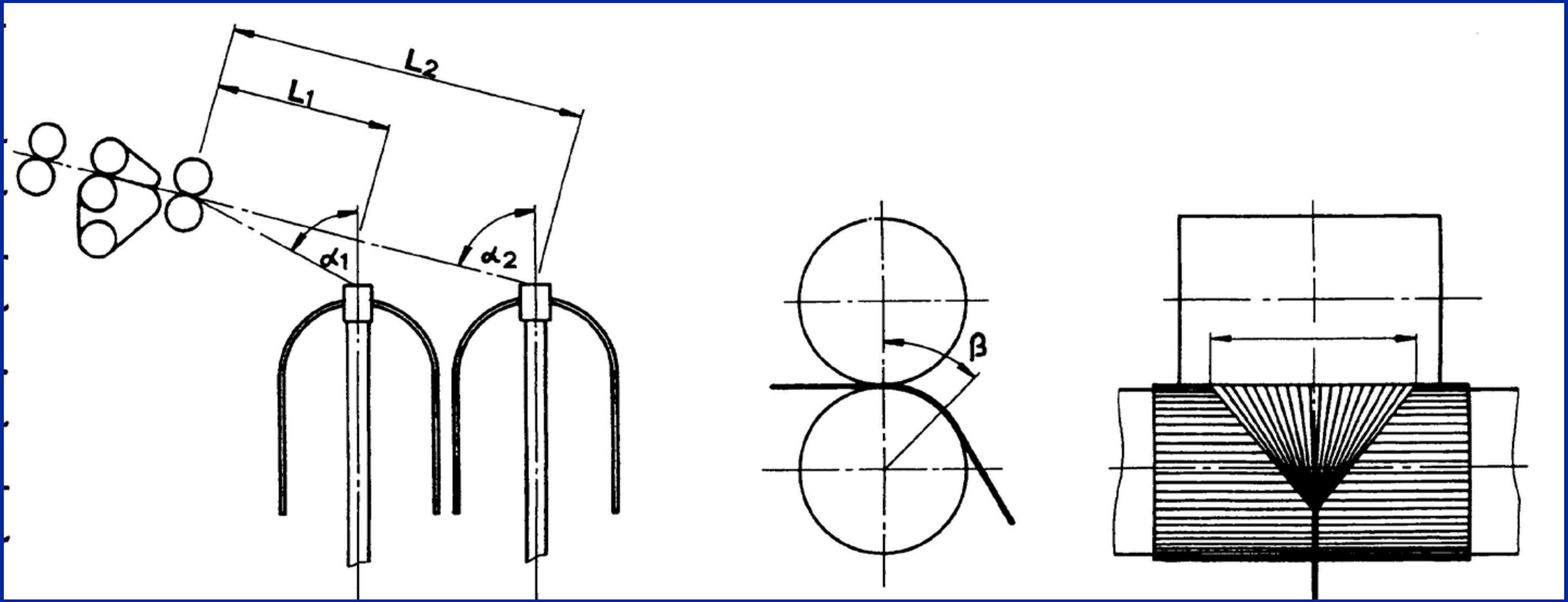
Draw slivers *cans (1)* *transport rollers (2)* *drafting arrangement (3*

unsupported length (5) *flyer (6)* *spindle (7)* *bobbin (8)*

the bobbin rail (9) *lever (10)*

Effect of the arrangement of bobbins in two rows

•This leads to different angeles (alpha), This leads to different rolling conditions at the entry point
of the roving to the flyer top This arrangement is economical in space,
•Difference in the angle (Beta) swept out by the two rovings at the front cylinder



The operating regions of the roving frames

<u>The creel:</u> *Above the cans there are several rows of driven rollers*

<u>The drafting arrangement:</u>

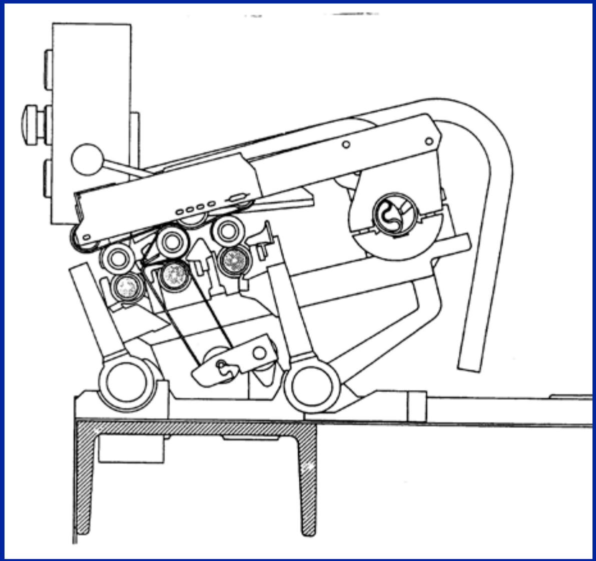
3 over 4 arrangements is found relatively rarely

Double apron system is standard.

double apron arrangement enables drafts of 20 and higher.

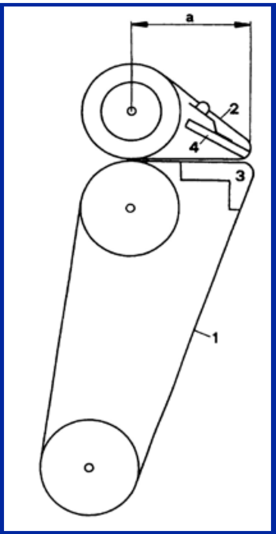
In general 3 over 3 is used

Break drafts are usually selected around 1.1 (1.05 to 1.15) for cotton and slightly higher for synthetic fibers



<u>*The apron:*</u>

•The upper aprons (2) are short and made of synthetic rubber held taut by tensioning devices (4) lower aprons (1) are longer, They run over guide bars (nose bars) (3) to a position close to the nip line of the delivery rollers cradle length (a), must be adapted approximately to the staple length



Spindle and flyer

Imparting twist:

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

$$Turns/meter = \frac{flyer\ rotation\ (rpm)}{delivery\ speed\ (m/\min)}$$

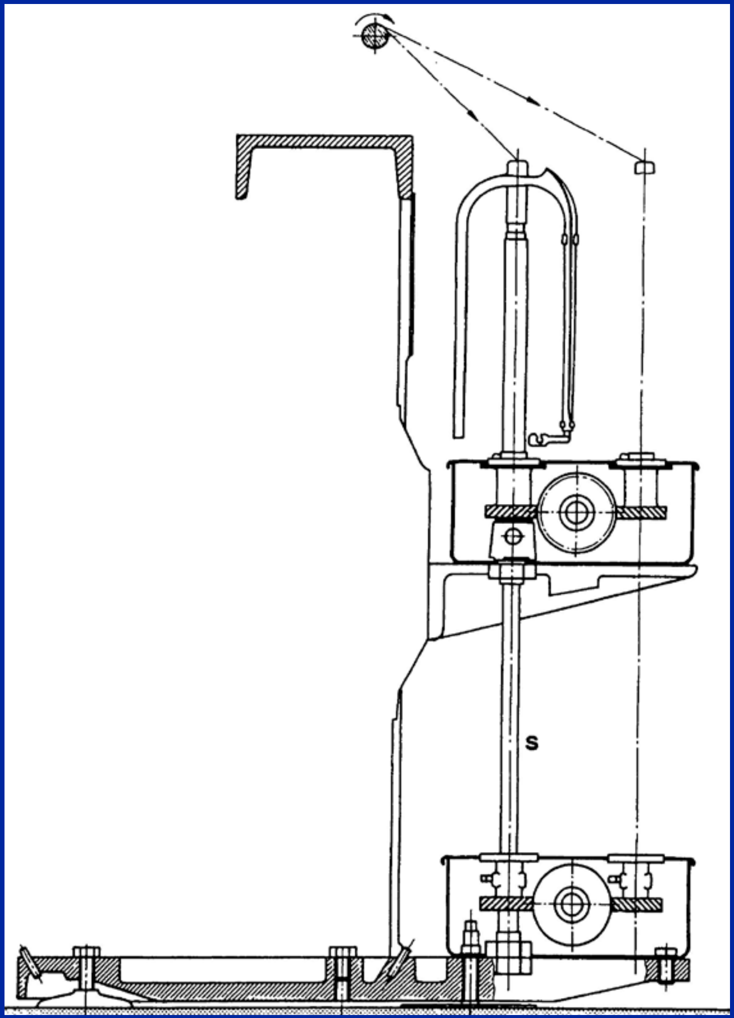
The spindle:

The spindle is simply a support and drive element for the flyer

The flyer

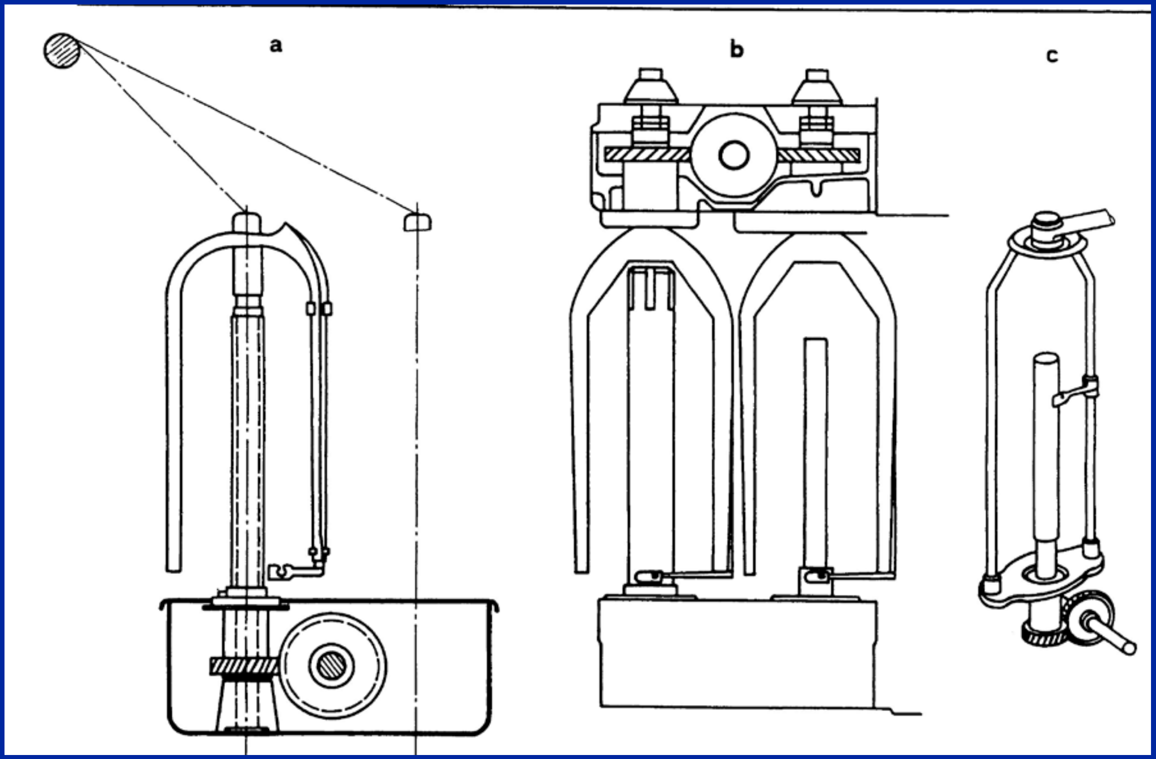
one of the two legs has usually been "hollow", i.e. with a deep guide groove that is open in a direction opposite to the direction of rotation

the strand has low level of twist " only protective twist"



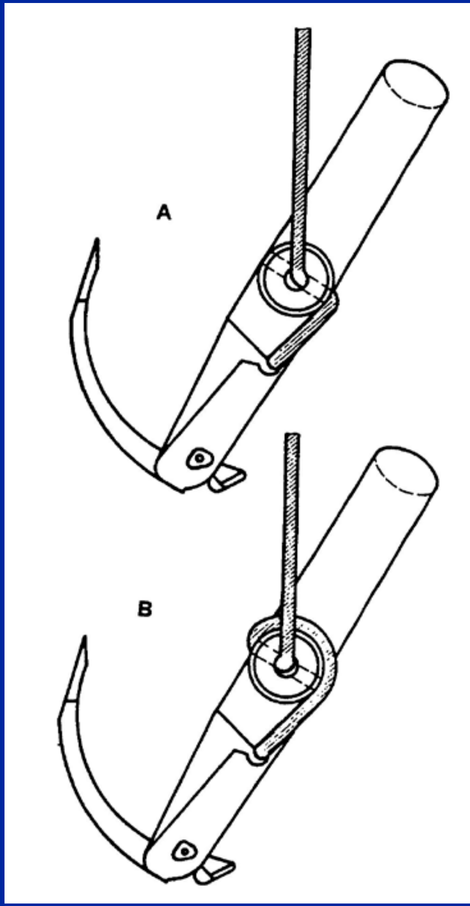
Various designs of flyer

Derive of top mounted flyer

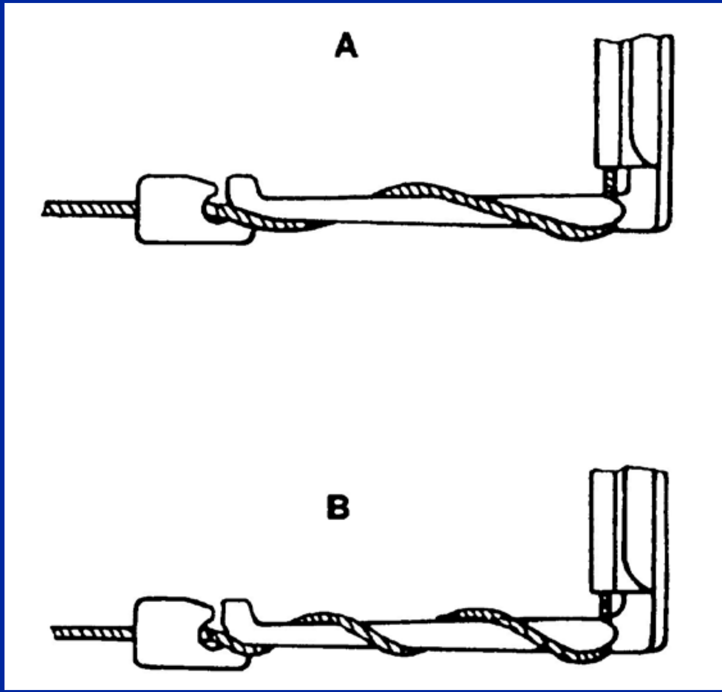


Spindle mounted flyers Top mounted flyers Closed flyers

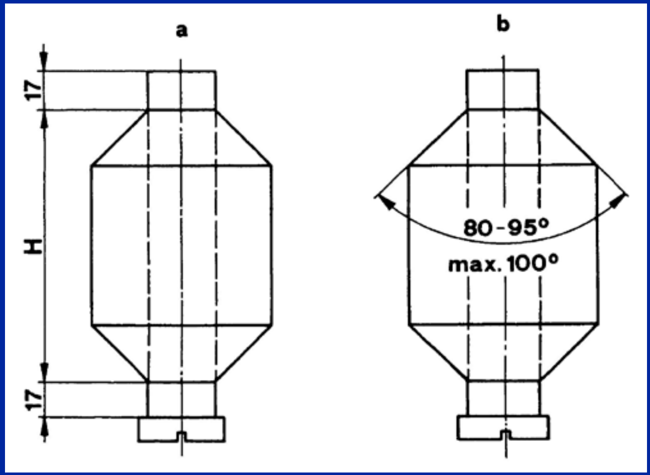
Winding of the bobbin:



Entry of the strand into the flyer top

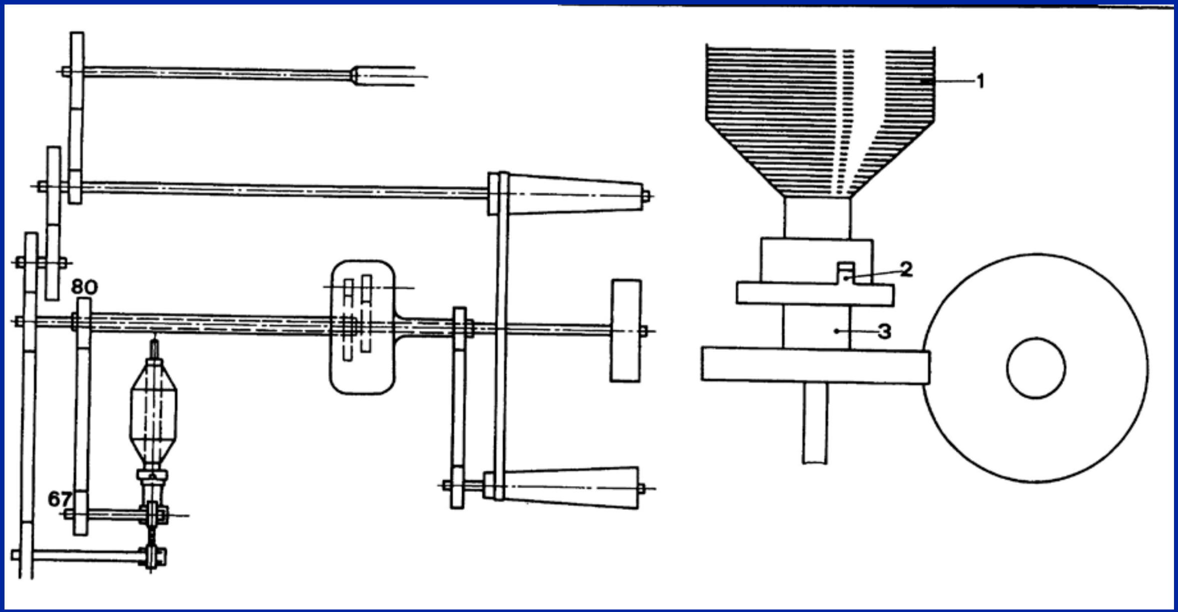


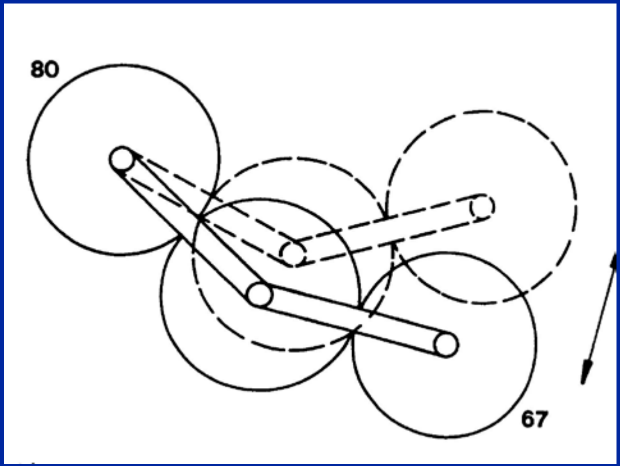
guidance of the roving by the presser arm



The bobbin form

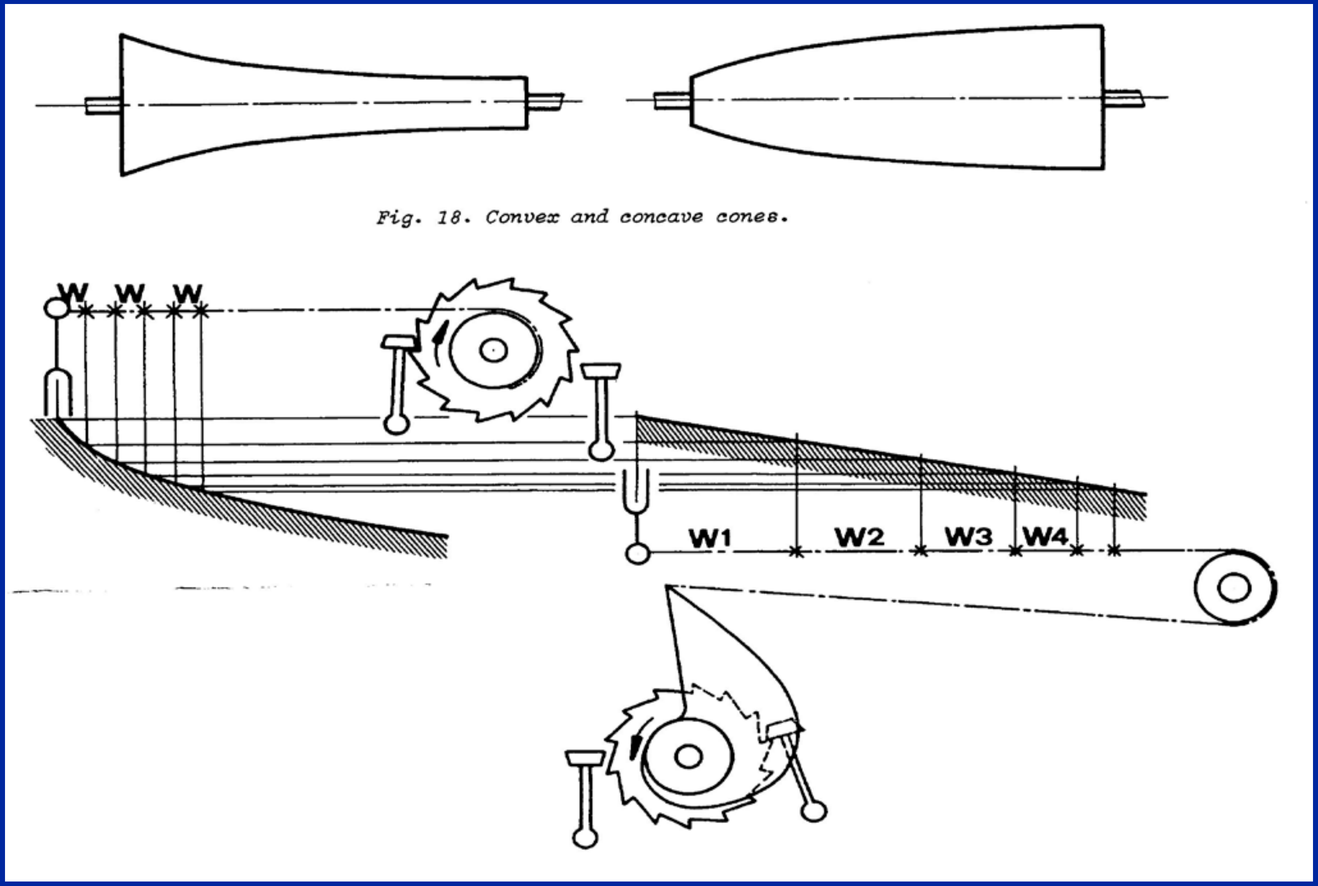
Winding of the bobbin:



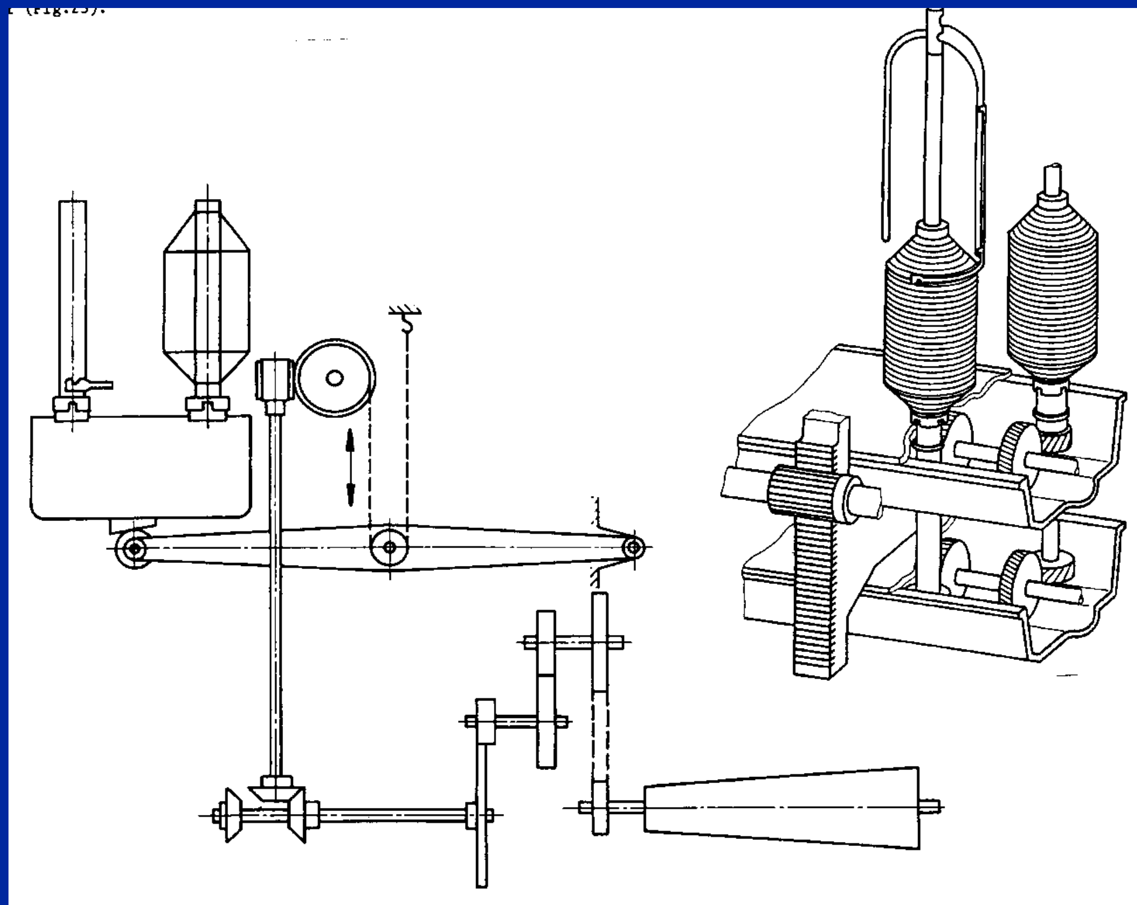


Swinging joint

The cone drive transmission *Cone profile*



The lifter motion



Automatic doffing

The Ring Spinning Frame

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 160 years, the machine has passed many considerable modifications, but the principle of yarn forming remained unchanged. In spite of the many yarn forming introduced, 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.)

Ringspinnmaschine G 33

Basic Principle of Yarn Forming

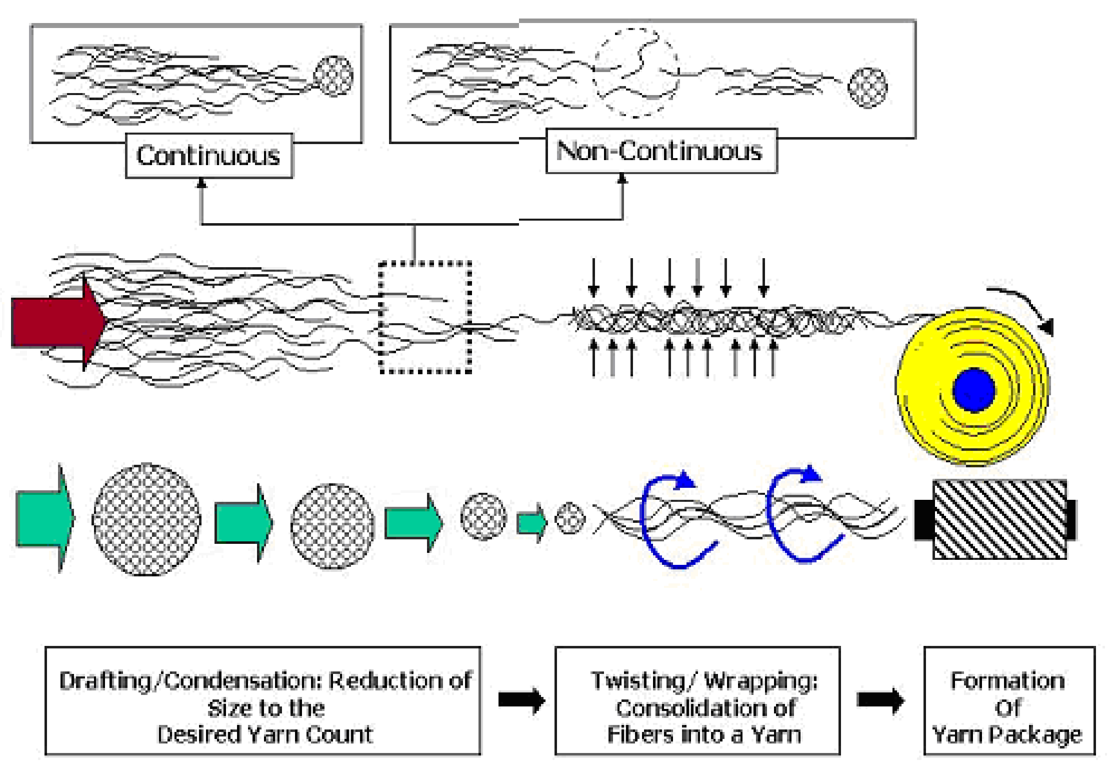
Basic Principle of Spinning:

- Drafting mechanism
- Consolidation mechanism
- Winding and package forming mechanism.

- The ring spinning is characterized by two main features:

- 1) Continuity of fiber flow roving to yarn.

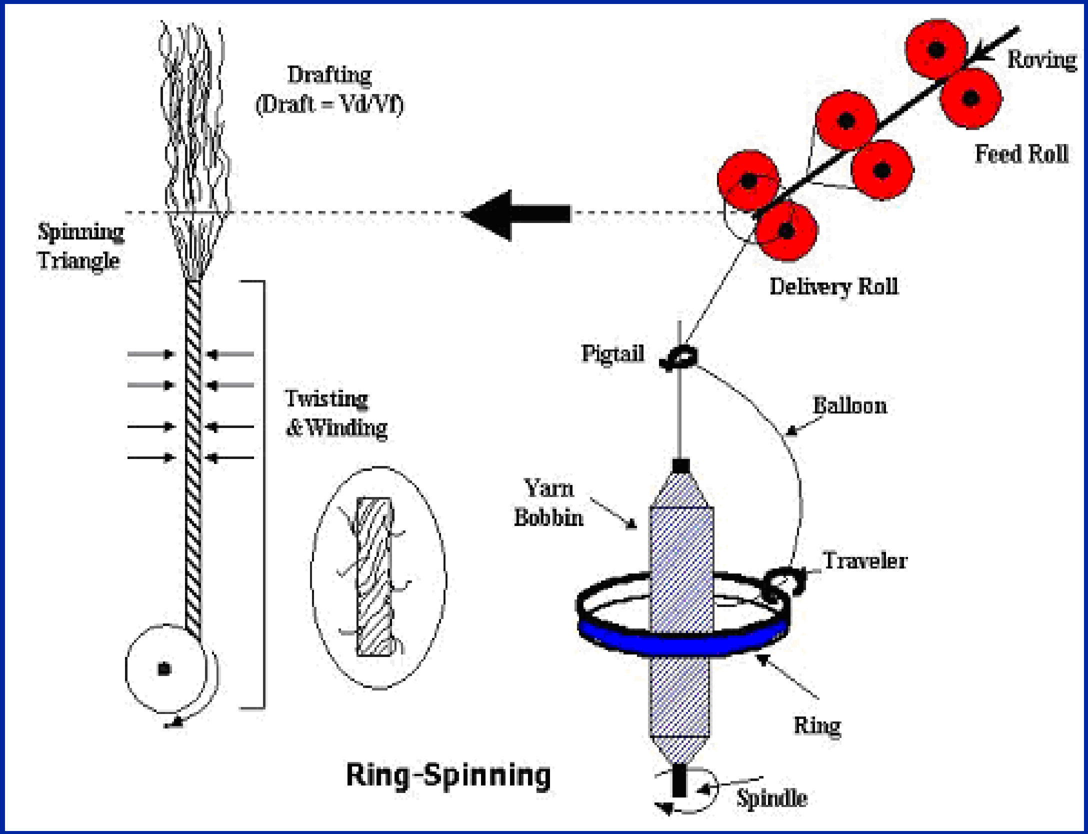
- 2) Tension-controlled spinning process.



The Basic Principle of Spinning

Principle of Twist Insertion Mechanism

In practice, spindle speed (rpm) is used instead of traveler speed (rpm) in the above equation; this results in a slightly over-estimated value of twist because $n_{spindle}$ is slightly greater than $n_{traveler.}$ The difference in speed between spindle and traveler causes the yarn to wind on the package. The increase or a decrease in twist is mainly a result of a change in the speed of the delivery roller. Thus twist affect level affect productivity.

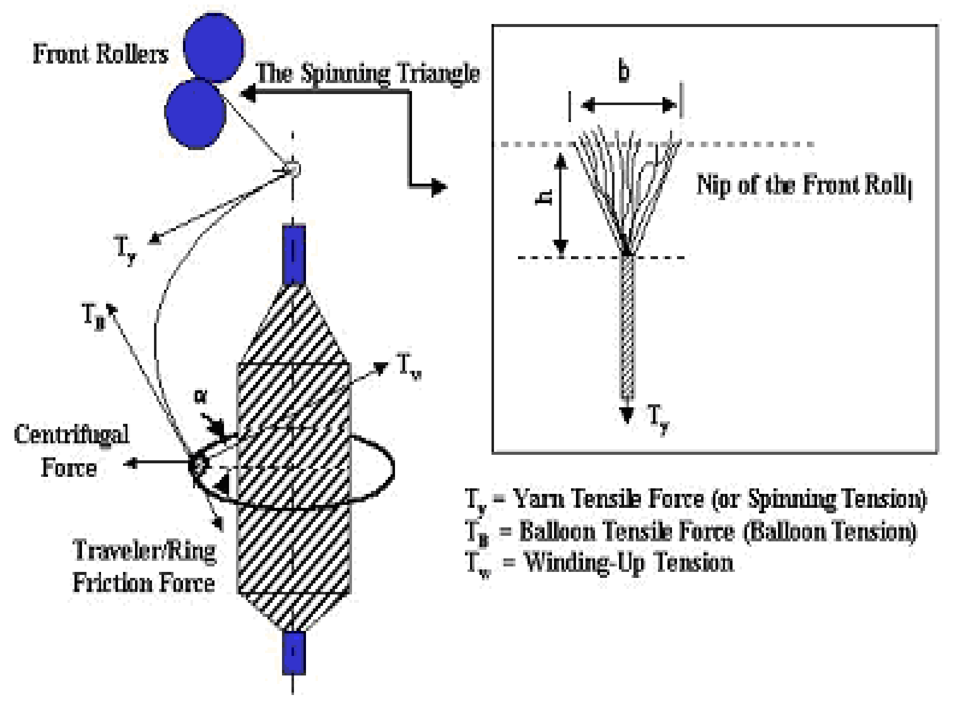


$$Twist = Turns / meter\,(t.p.m) = \frac{n_{spindle}\,(rpm)}{V_{delivery}\,(m/\min)}$$

Traveler Speed/Spinning Tension Relationship I

Spinning tension is defined as the tensile force applied on the yarn at the onset of twisting: that is the yarn tension at the point where the fibers in the spinning triangle are being twisted. The critical importance of this parameter lies in the fact that it contributes largely to both the quality of ring-spun yarn, and the spinning performance. Spinning tension results in a closed packing of fibers during twisting, which enhances the yarn strength. Variation in spinning tension directly results in variation in yarn strength. Excessive tension or tension peaks may result in end breakage during spinning. In fact, more than 80% of end breakage during ring spinning is believed to result from tension peaks at the spinning triangle.

The relationship between traveler speed and spinning tension can be demonstrated by the following equation (Stalder, 1991):. where $\mu_{r/t}$ = the coefficient of friction between ring and traveler, a = the angle between yarn from traveler to bobbin and a straight horizontal line from traveler to spindle axis, m_t = traveler mass, V_t = traveler speed, and d_r = ring diameter. Note that the term (m_t. V^2_t / d_r) represents the centrifugal force.



Forces Applied on the Yarn During Ring-Spinning

$$T_y = \frac{\mu_{r/t}}{\sin\alpha}\frac{m_t.V_t^2}{d_r}$$

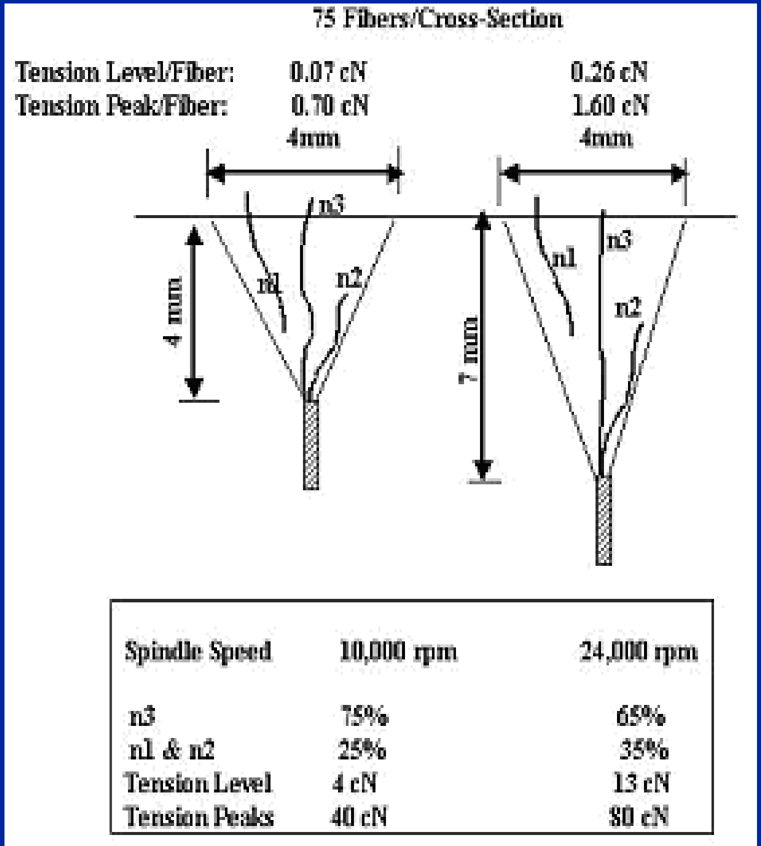
The Spinning Triangle I

In the spinning triangle, different fibers have different tensions depending on their position in the triangle. When fibers are released from the nip of the front roller, those exhibiting high tension tend to move toward the center displacing the initially central fibers to the outer layers. This phenomenon is called "fiber migration" and its main effect is to enhance fiber cross-linking, and consequently to improve yarn strength. The dimensions of the spinning triangle (width and height) determine the extent of fiber/machine interaction in this critical zone. the width of the triangle is a function of the amount of draft or the total number of fibers delivered, and the pressure on the front roll. The height of the triangle, on the other hand, is quite sensitive to the spinning tension.

three different fiber arrangements in the spinning triangle

n_1 = fibers which are only held at one end by the nip of the front roller while the other end is free

- **n_2 = fibers which are only held at one end by the twisting point while the other end is free**
- **n_3 = fibers which are held by both the nip of the front roller and the twisting point (i.e. fibers firmly held by the triangle). Those fibers exhibit a mean fiber length longer than the height of the spinning triangle.**



Effect of Spindle Speed on the Spinning Tension

The Spinning Triangle II

Any fiber entering the spinning triangle that does not belong to any of the above categories will typically be too short (fiber fragment) and, if not held by other fibers, will likely result in fly generation.

Two forces are acting against each other; the spinning tension T_y and the fiber strength T_f. Perfect dynamic balance is achieved, if all fibers in the spinning triangle will equally share the support of the spinning tension. (all fibers in the triangle belong to the n_3 group). If the majority of fibers in the triangle belong to the other two groups, a smaller number of fibers will be supporting the load exerted by the spinning tension. This situation may result in tension peaks and a spinning failure or end breakage at the spinning triangle.

The spinning triangle should have optimum dimensions to allow spinning stability. In particular, the triangle should not be too small to provide a room for fiber exchange of position (fiber migration), and not too large to allow the majority of fibers to be held in the triangle (high hairiness). This latter point was the driving force of a new ring-spinning development called the “compact” spinning.

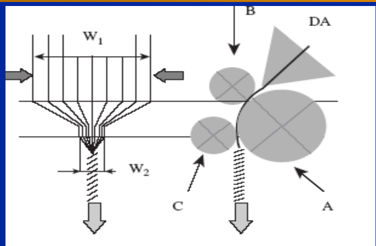
Modification of Ring Spinning

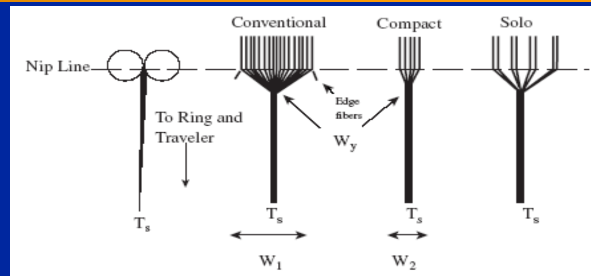
1 – Compact Spinning

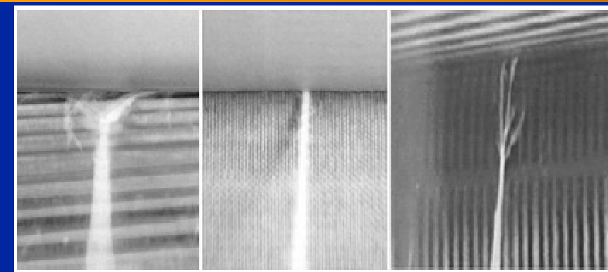
2 – Siro Spinning System

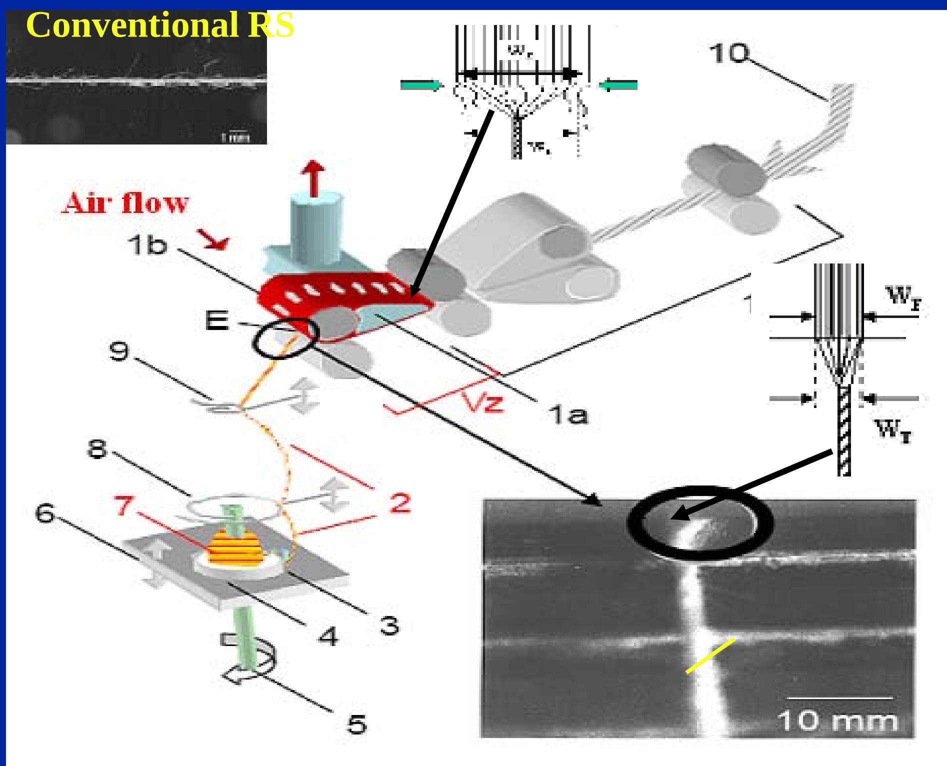
3 – Core Yarn Spinning

Principle of Compact Spinning









1)Draft 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

Factors Affecting Compact Spinning

Condensing zone is heart of compact spinning.

Fiber length, fineness and stiffness are factors affecting the fiber transport by air flow, this necessitates apron moving to be less than delivery rollers (condensing) .

Changing the perforation width increases air velocity.

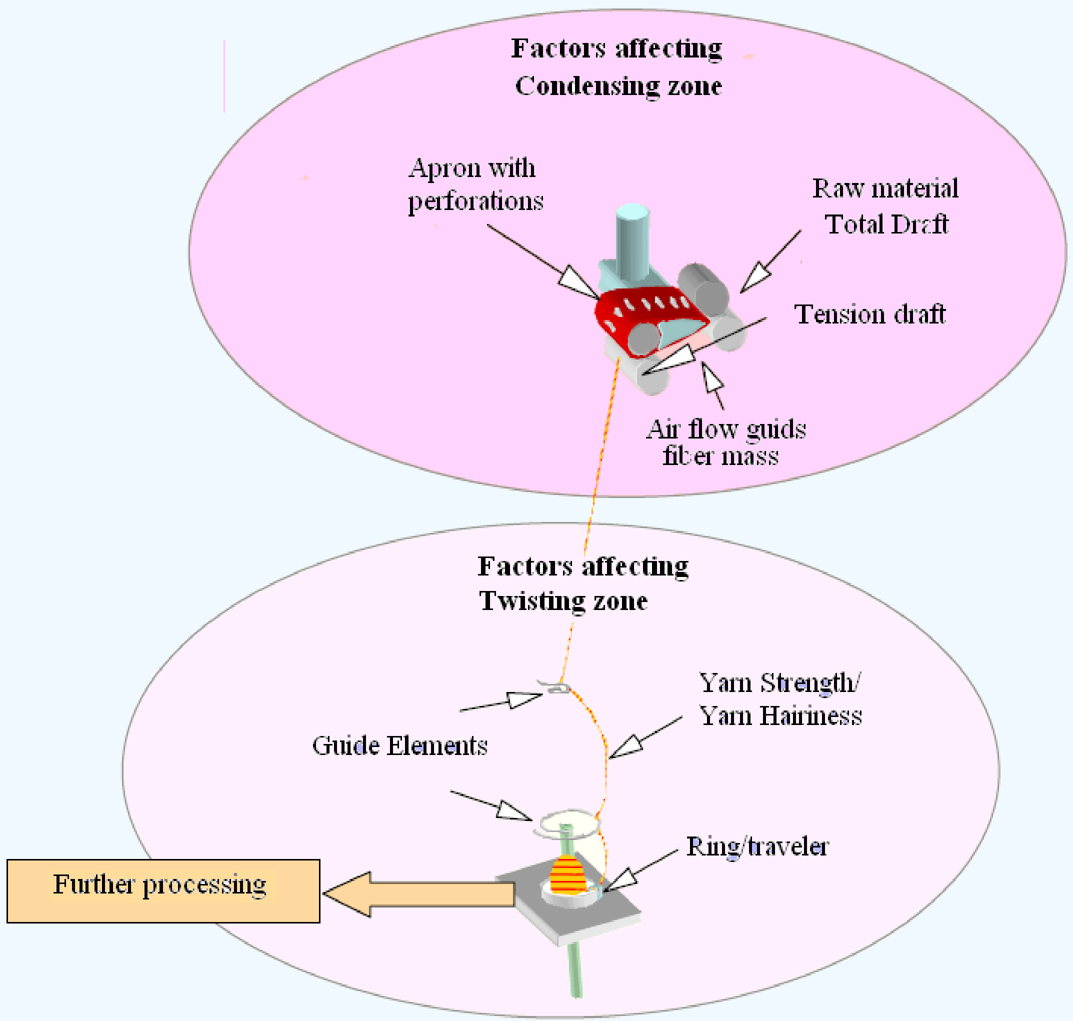
Smooth guides gives better twist propagation.

Hairs of less than 2mm

give better cover factor,

Hairs> 3 mm are

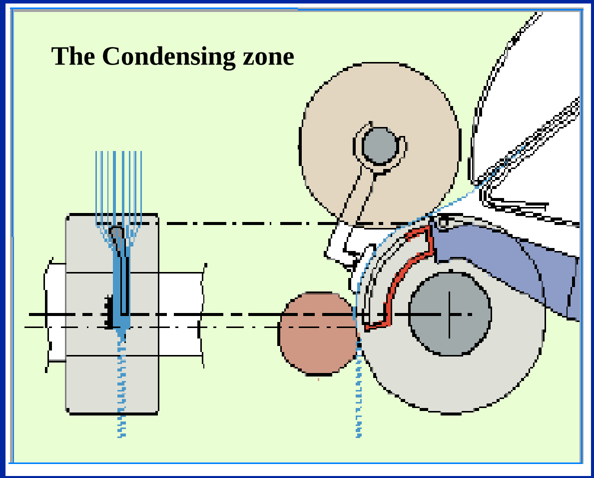
Problematic for processing

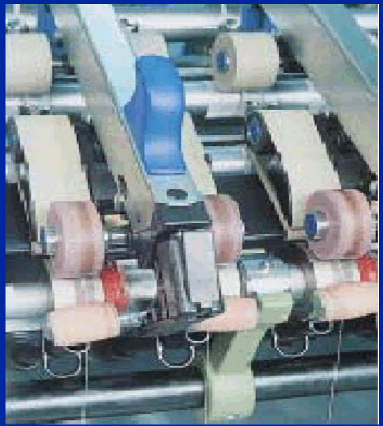


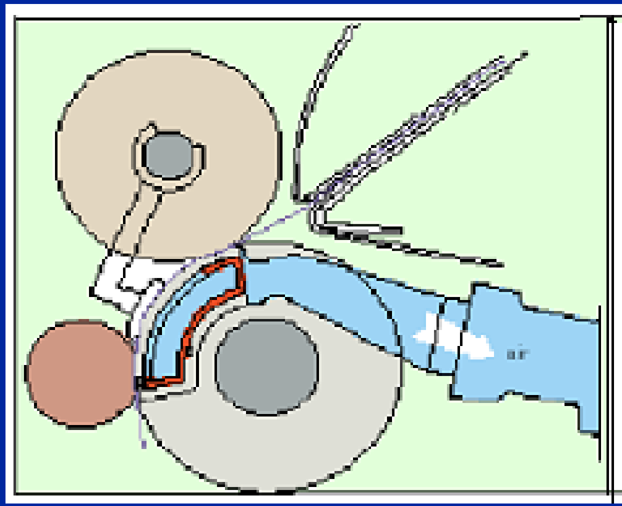
Rieter Com4 Compact Spinning System

The Com4 system was conceived by Dr. Ernst Fehrer, the founder of friction spinning. The condensing system of **Rieter** consists of a perforated drum, just situated after the double apron arrangement and works simultaneously as a delivery roller of the draft system. On the perforated drum, two pressure are situated. The first roller acts as nipping point of the draft system, while the second roller works as twist stop to prevent twist escaping to the condensing zone. The fiber bundling occurs through the suction zone, which is found inside the perforated roller, and in the region between the two pressure rollers. Under this air suction , fibers merging from the delivery nip of the drafting unit are held against the drum surface and moved at the same circumferential speed as the drum surface. In ATME 2000 Rieter south Carolina introduced an innovation in the air guide providing more fiber compactness both against the drum and in lateral direction. This innovation is known as K44-C.om4.

Perforated rollers



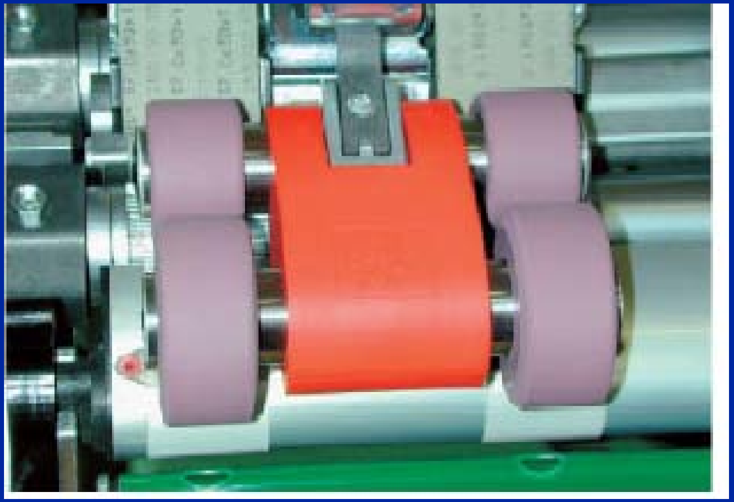


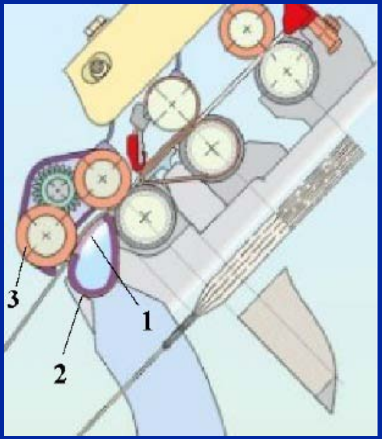


Details of Compact Spinning

Sussen Elite Compact Spinning System

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



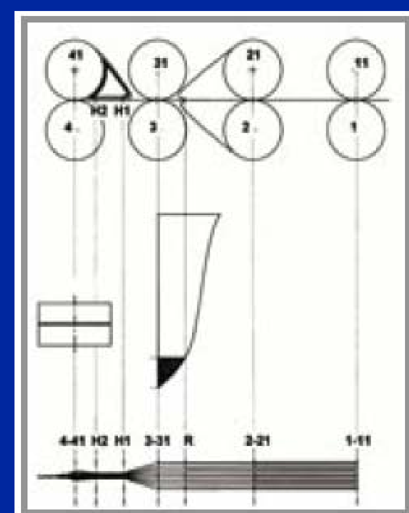


1) Profile tube, 2) Lattice apron, 3) Delivery top roller

Profile tube with inclined lattice

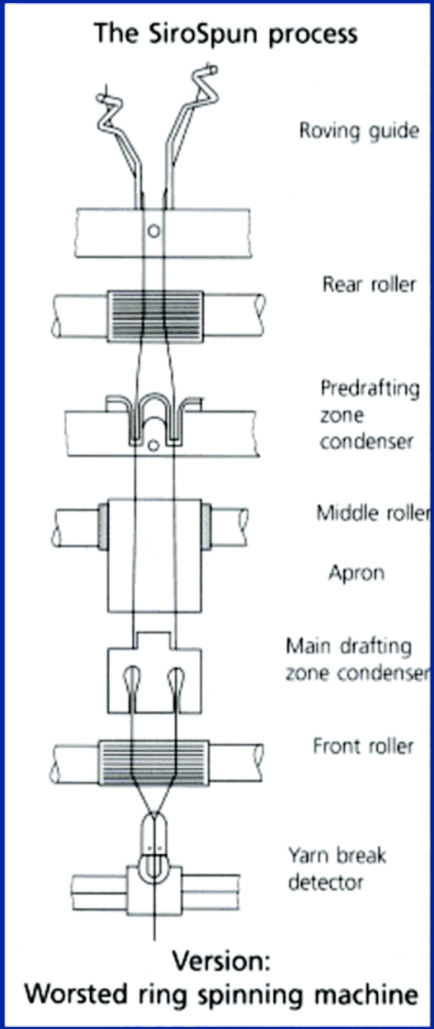
Zinser Compact System

The system of Zinser, is characterized by extending the draft system by a double roller. A perforated apron is moved over the upper roller, where the suction profile element is found. Between the delivery roller and the perforated apron, the condensing zone occurs. The roller pair is working in a classical way as in ordinary draft system.



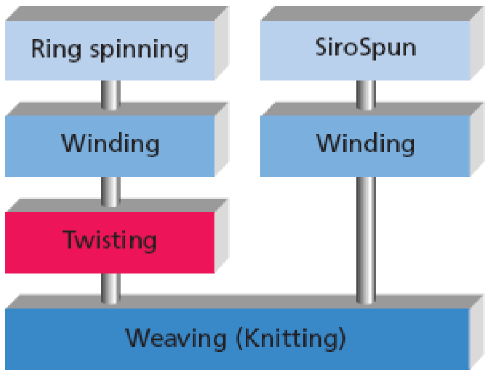
Siro Spun Twofold Yarn

The **SiroSPUN™** process adapted some of the self-twist discoveries of CSIRO to the ring spinning technology of the worsted system, and combined spinning and doubling in the one operation. The technology maintains two separate strands during the spinning process, and this allows a number of fiber-binding mechanisms to operate before the strands are twisted about each other. An important aspect of the SiroSPUN™ system is a simple device to break out the remaining strand if one of the strands should be accidentally broken. SiroSPUN™ is used also for short staple fibers as cotton and blends. The roving strands, which are drafted parallel, are combined after passing the front rollers at the exit from the drafting system, with some twist being produced in the individual strands right up to the nip point. Once past the front roller of the drafting system, the two strands are combined producing a twofold-like yarn. The yarn has uni-directional twist like a singles yarn but the fibers are bound sufficiently for the yarn to survive weaving.

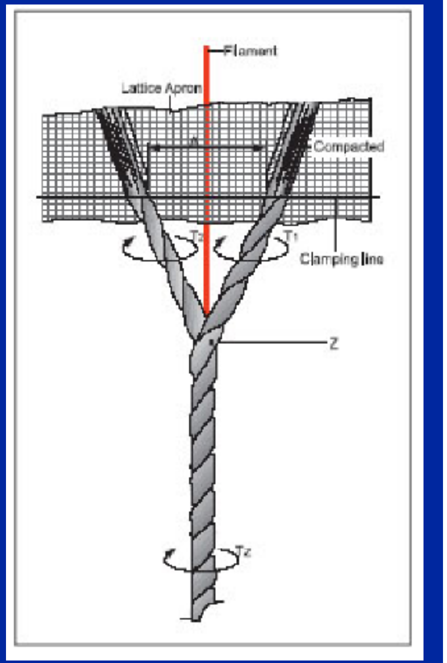


Multi folded Threads

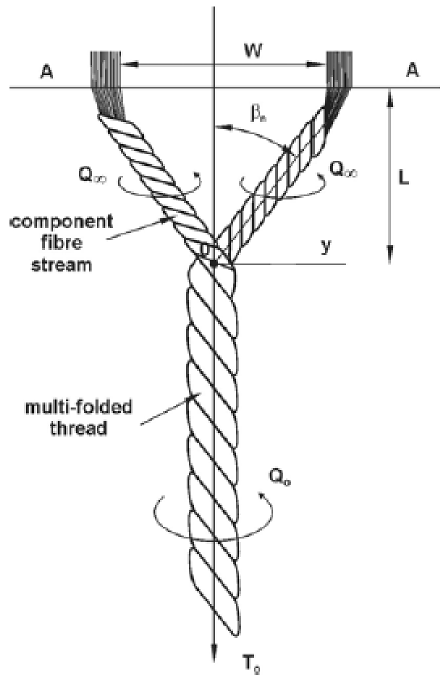
Advantages of Siro-Spun



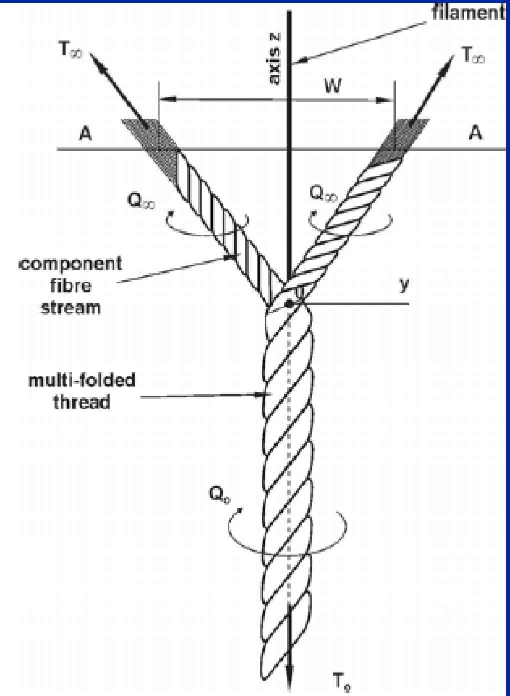
The SiroSpun process compared with the conventional ring spinning process.



Siro-core compact yarn



Scheme of a twisted classic multi-folded thread



Scheme of a compact multi-folded thread with core

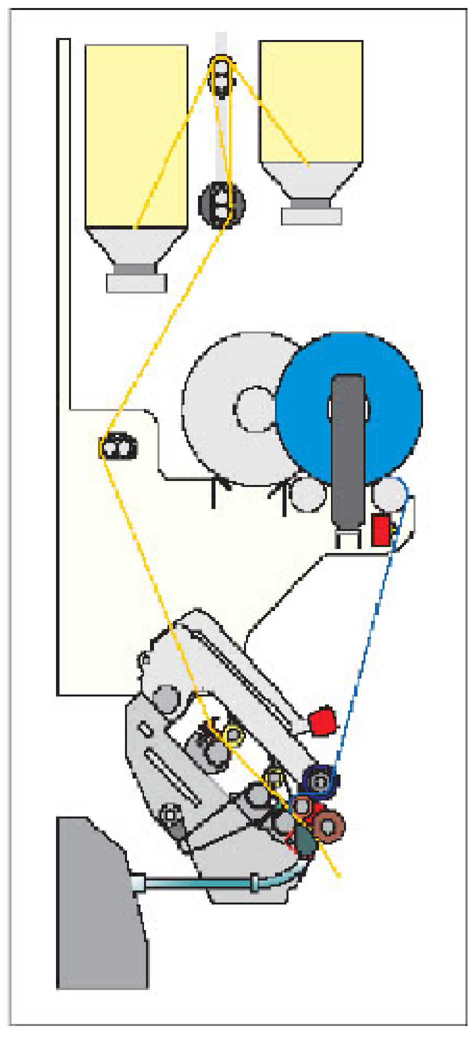
To achieve higher quality requirements, multi folded threads are manufactured on compact yarns twisted together.

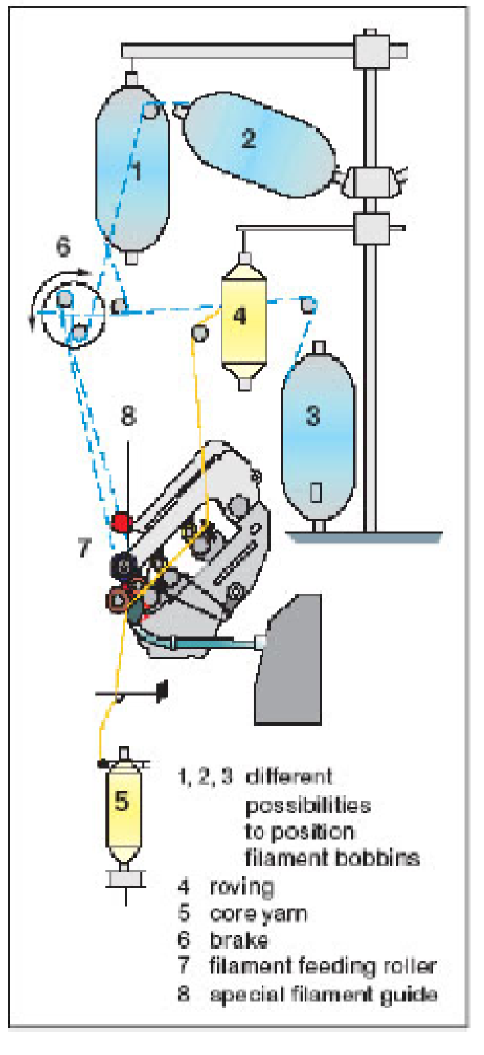
Different Types of Multi Folded Yarns

Siro Yarn Single yarn compact Plied Multi Plied compact R.S. Plied

Core Spun Yarn

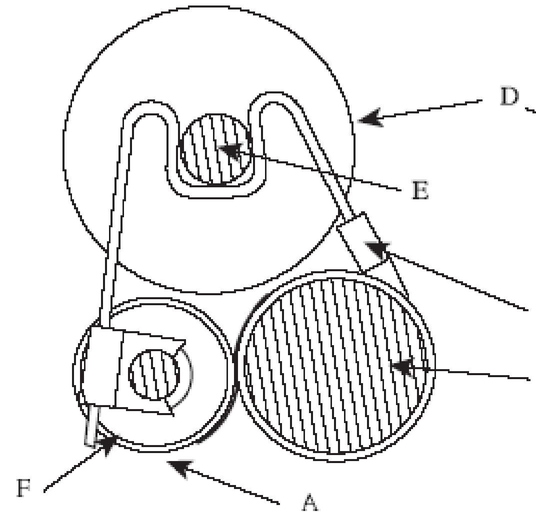
Core Spun Yarns are produced on Ring Spinning machines or Compact R.S Machines. Essentially is adapting the tension of the filament yarn. Also the percentage of Core/ sheath determine the yarn characteristics.

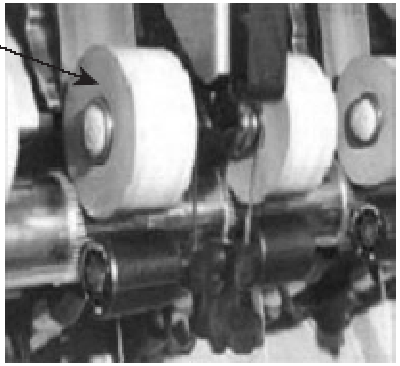




Solo Spun System

two strands of roving passing through the same drafting unit but separated so that they emerge from the front drafting rollers a fixed distance apart. They then converge to a point at which the twist torque propagating from the yarn ballooning region inserts twist into the separate strands and plies the twisted strands together to form the twofold yarn. The strand twists propagate to form two very small, almost imperceptible, spinning triangles at the front drafting rollers. The strand and ply twists are of the same twist direction. As fibers leave the front drafting rollers, they are incorporated into the strands in a similar way to conventional ring spinning. Therefore, unless the strand twist is high, there will be some fiber lengths projecting from the strands. The propagation of strand twist toward the nip of the front rollers means that a given projecting length will be rotating about the axis of the strand into which the remaining length of the fiber is twisted.





Solo spinning system: A = yarn, B = bottom front rollers, C = clip, D = top front roller, E = top roller shaft, F = Solo roller.

Non-Conventional Spinning Systems

1 – Open end Spinning

2- Core Spun Rotor Spinning (Rotona)

3 – Air Jet Spinning

Murata Air Jet Spinning

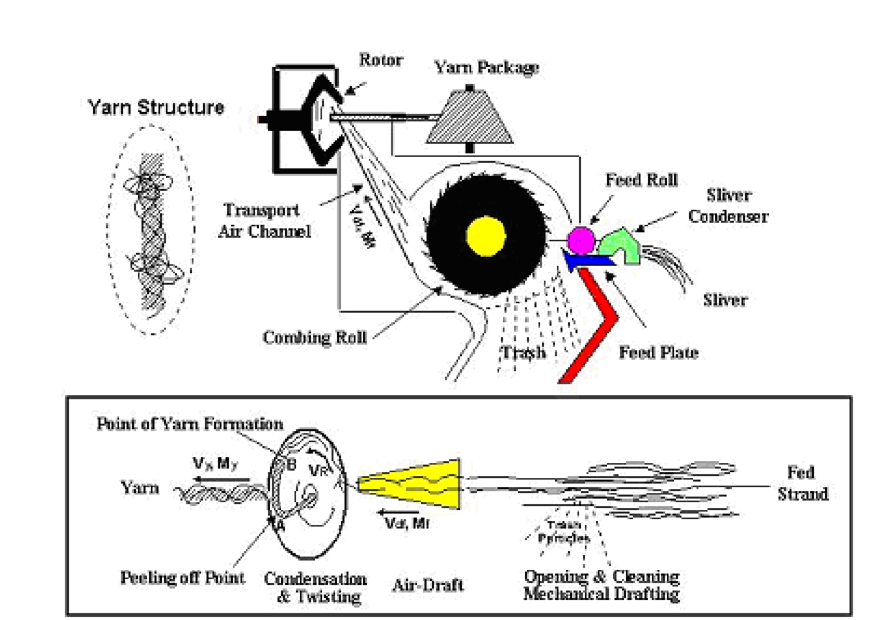
Murata Vortex Spinning

Principle of Open End Spinning

In rotor spinning, the drafting mechanism consists of three main operations: (i) mechanical opening using an opening roll, (ii) air drafting using an air stream and transporting duct, and (iii) doubling mechanism. The mechanical drafting is achieved using a toothed opening roll. In order to minimize fiber disorientation, the airflow in the duct should have a velocity exceeding that of the surface speed of the opening roll. To obtain such an airflow, the inside of the rotor is run at a vacuum which may be achieved by designing the rotor with radial holes to allow the rotor to generate its own vacuum (self-pumping effect).

The continuity of mass flow in rotor spinning is determined by the following equation (Lord, 1981):

M_{fibers} = the mass of fibers in the air duct, M_{yarn} = the mass of output yarn, V_f = fiber velocity, V_y = yarn velocity, n_{df} = the number of fibers in the air duct at the inlet of the rotor (<10), n_{yf} = the number of fibers per yarn cross-section. The above mass-flow equation indicates that the number of fibers per yarn cross-section is a function of the number of fibers landing inside the rotor, fiber velocity, and the yarn velocity.

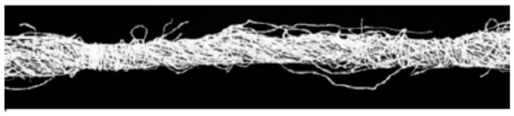


Principle of Rotor-Spinning

$$n_{df}\,tex_f V_f = n_{yf}\,tex_f V_y \quad \rho$$

$$Thus,\ \frac{n_{yf}}{n_{df}} = \frac{V_f}{V_y}$$

Factors Influencing Rotor-Spinning Performance I


Rotor Spun

Rotor-Yarn Structure :

The low tension, and the subsequent lack of torque control results in a structure that is unique for rotor-spun yarns. In general, this structure consists of a core, which is fully twisted (similar to ring-spun yarns), and an outer-layer that is partially twisted. In addition, some fibers called "belly or belt fibers" are randomly deposited on the yarn surface. These fibers result from the interfacing between the processes of laying fibers on the rotor-collecting surface and the peeling off of the yarn from the collecting surface (see previous Figure). This interface occurs once per each rotor revolution. These bellybands are laid at these times; they may take a clockwise or an anti-clockwise direction.

As a result of the partial true twist in rotor-spun yarns, the yarn has a natural curling (or snarling) tendency, similar to ring-spun yarns. The major difference, however, lies in the fact that in rotor-spun yarn, the natural torque resulting from the real twist is partially balanced by a torque caused by the wrapping effect of the belly bands.

The curling tendency can be determined by the residual twist or the difference between the measured yarn twist and the nominal twist (ΔT). The assumption made here is that the higher the value of *T, the lower the curling tendency, and the higher the number of bellybands or the higher the level of their tightness. Typical ΔT values may range from 10% to 40%. Using this value, Artzt et al examined the cause and effect of curling tendency and made the following important points:

- **The main spinning parameters influencing the twist difference (or curling tendency) are rotor speed and rotor diameter (or the ratio of rotor diameter to fiber length, d_R/FL).**

Factors Influencing Rotor-Spinning Performance II

•• The increase in rotor speed generally results in an increase in ΔT or a decrease in the curling tendency, for all rotor diameters. For a given level of twist, rotor speed was independent of the number of bellybands. Therefore, the decrease in the curling tendency with the increase in rotor speed was attributed to an increase in the tightness of bellybands rather than their frequency.

· The decrease in rotor diameter was generally found to increase the twist difference, or decrease the curling tendency.

· The steadily increase in rotor speeds leads to ever smaller rotors with the consequence of greater fiber randomness, less control on fibers in the flight path, more fiber bellybands, less curling tendency, and, consequently, more shift away from the structure of ring-spun yarn structure.

· For a given spinning condition, yarns with high curling tendency also display high yarn extensibility by virtue of their "liveliness". In general, yarns with only 5% elongation are practically "dead". They also lead to finished articles with very little elasticity. The low extensibility has an effect on the fabric tearing strength in that the low extensible yarns are not in a position to build up a corresponding network of force distribution. When tear stress is applied, the individual threads are virtually stressed one after another, which leads to a corresponding low overall tear propagation strength.

• Yarns with high curling tendency are generally difficult to handle in weaving and knitting processes.

Factors Influencing Rotor-Spinning Performance III

Effect of Rotor Speed:

•In comparison with ring spinning, this represents less of a challenge because of the much smaller rotating mass than the spindle carrying the yarn package. In the early generation of rotor spinning, the increase in rotor speed was hindered by mechanical limitation. From 1967 to 2000, the rotor speed was increased from 25,000 rpm to 150,000 rpm. This dramatic increase was associated with a simultaneous reduction in the rotor diameter and with more innovative rotor bearing systems.

•The delivery yarn speed in rotor spinning is determined by the rotor speed and the amount of twist inserted: ($n_{yf}/n_{df} = V_f/V_y$). Accordingly, the increase in yarn linear speed (or the production rate) requires ($V_f \cdot V_R = Bd_R\, n_R$), an increase in rotor speed.

$$V_{yarn} = \frac{n_{rotor}}{twist}$$

•Recall that according to equation of mass flow, the ratio between the number of fibers in the yarn and those at the inlet is determined by the ratio between the fiber velocity and the yarn velocity ($n_{yf}/n_{df} = V_f/V_y$). If the fiber velocity is approximately equivalent to the surface speed of the rotor ($V_f \cdot V_R = \pi d_R\, n_R$), the ratio n_{yf}/n_{df} will be approximately equal to $B.d_R.T$, where T is the twist in tpi. This means that the number of fibers per yarn cross-section is determined by the amount of twist for a given rotor diameter, and the number of fibers entering the rotor. Also recall that the ratio n_{yf}/n_{df} represents the number of back doubling in the process, which means that the level of twist (n_R/V_y) and the rotor diameter determine yarn uniformity.

Factors Influencing Rotor-Spinning Performance IV

Spinning Tension:

•Several equations have been developed to describe the yarn tension during rotor spinning. The Rieter group proposed the following equation:

$$T_{out} = \left(T_p + \frac{tex_{yarn} \cdot \omega_r^2 \cdot R_r^2}{2} \right) e^{\mu\pi/2}$$

where T_{out} = the yarn tension outside the rotor, T_p = the yarn tension at the peeling off point (point A in Figure), Tex_y = the yarn linear density in tex, T_r = the rotor rotational speed in radians, R_r = the rotor radius, and μ = the coefficient of yarn-rotor surface friction.

Assuming T_p to be very small, then the equation can be reduced to:

$$T_{out} = \left(\frac{tex_{yarn} \cdot \omega_r^2 \cdot R_r^2}{2} \right) e^{\mu\pi/2}$$

•The above equation indicates that spinning tension in rotor spinning is particularly sensitive to the term (T_r^2 R_r^2), which represents one of the primary design criteria of the spinning unit. The importance of yarn tension lies in its significant effect on yarn quality. Previous studies showed that there is a linear relationship between the variation in yarn tension and the yarn mass variation (Uster C.V%). The increase in rotor speed or the increase in rotor diameter results in a consistent reduction in yarn breaking elongation. This effect is attributed to the increase in yarn tension as a result of the increase in the term (T_r^2 R_r^2).

•Increasing the rotor speed was associated with a simultaneous reduction in rotor diameter. The above equation represents a reasonable justification to this dual trend. In today's technology, the maximum rotor speed is about 150,000 rpm. This speed is associated with rotor groove diameters of 28 to 30 mm.

•Rotor speed limiting factors: the centrifugal force on the fiber mass inside the rotor, peak yarn tension, and the bursting stress of the rotor.

Factors Influencing Rotor-Spinning Performance V

Centrifugal Force on the Fiber Mass Inside the Rotor:

•The centrifugal force (CF) on a fiber mass m_f deposited in the rotor groove is given by the following equation: $CF = m_f . R_f \omega_r^2$ Thus, the increase in rotor speed results in a substantial increase in the centrifugal force. The impact of this high centrifugal force is obvious, more trash and dust deposits in the rotor groove, and consequently, more yarn defects.

•In relation to yarn structure, the centrifugal force is expected to improve the fiber packing in the yarn. In addition, it is expected to result in a tighter wrapping of the yarn core by the bellybands (Artzt et al, 1989). As indicated earlier, this effect results in a smaller curling tendency in the yarn. Therefore, the increase in rotor speed and the simultaneous reduction in rotor diameter may ultimately be limited by their effects on yarn extensibility. As indicated earlier, yarns with low curling tendency also display low yarn extensibility by virtue of their "liveliness".

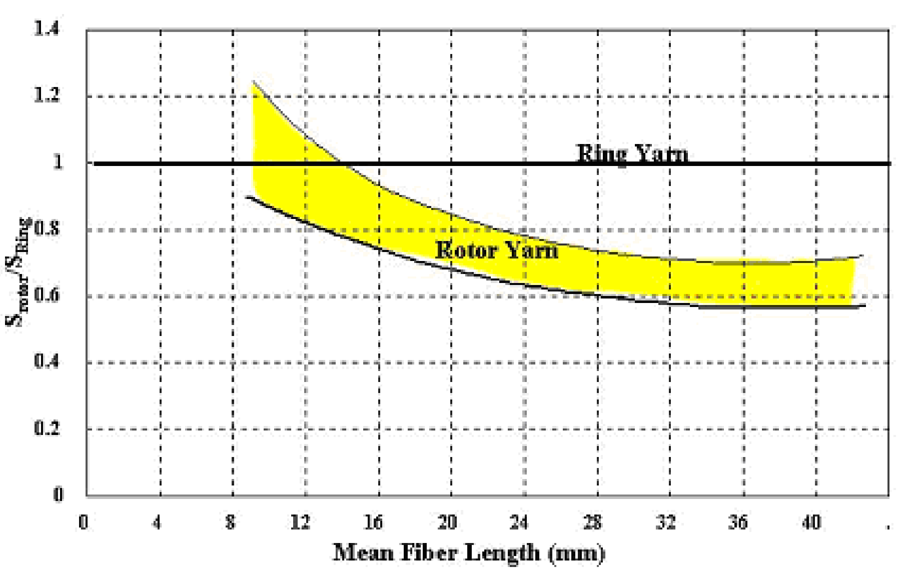
•Peak Tension:

•The Equation suggests that the spinning tension is proportional to the square of the rotor speed, ω^2 . As in case of ring spinning, the tension on the yarn during rotor spinning also exhibits peaks. The standard deviation of the tension, σ_{T_y} is proportional to the rotor speed at a power factor of more than 2 (Stalder, 1993): $\sigma_{T_y} \approx \omega_r^{>2}$

•This means that the increase in rotor speed may result in a rising in tension peaks even sharper than the average tension does. This effect increases the chance of more end breakage during spinning

Important Fiber Properties in Rotor-Spinning I

•From the above discussion, which clearly point at many of the fiber properties that are important in rotor spinning. Perhaps, the most important fiber property is fiber fineness. This is due to the structural limitations of rotor-spun yarn discussed earlier, which require more fibers per yarn cross-section to compensate for the loss of fiber contribution to yarn strength. For the same reason, fiber strength is another important characteristic. Indeed, the introduction of rotor spinning has greatly shifted the attention to these two properties.



Relative Yarn Strength of Rotor Yarn with respect to Ring Yarn at Different Fiber Length [Rieter Publications,1992]

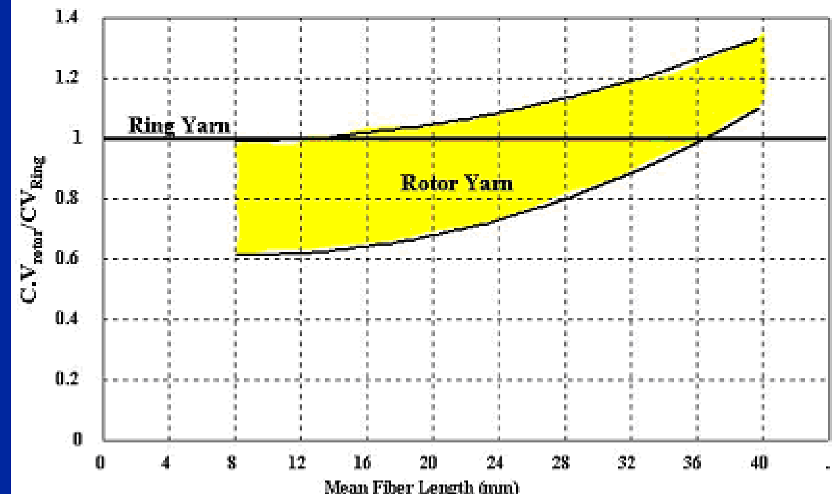
•With regard to fiber length, rotor spinning has altered the traditional view that ring spinning had established for many years; that is, fiber length is the most important fiber property. The reason for this is that long fibers are likely to be more disturbed by turbulent airflow than medium or short fibers.

•Some early studies revealed that long fibers result in lower rotor-yarn strength compared to that of ring-spun yarn.

Important Fiber Properties in Rotor-Spinning II

- They also revealed that the longer the fiber length, the higher the C.V% evenness of rotor-spun yarns compared to that of ring yarns. However, the key length parameter in rotor spinning is short fiber content. A high level of short fibers will result in low yarn strength and excessive ends-down.

- In addition to the above fiber characteristics, rotor spinning has set new standards for the level of fine trash and dust in the fiber strand. This is due to the fact that trash content is the primary cause of spinning ends-down. Values of trash percent of less than 0.2% in the fed sliver are recommended for rotor spinning.



Relative Yarn Irregularity (C.V% Uster) of Rotor Yarn with respect to Ring Yarn at Different Fiber Length [Rieter Publications]

Core Open-End Spun Yarns (Rotona)

The filament entered to the rotor through the shaft. The fibers forming the Open end yarn wraps around the filament, which has no twist.

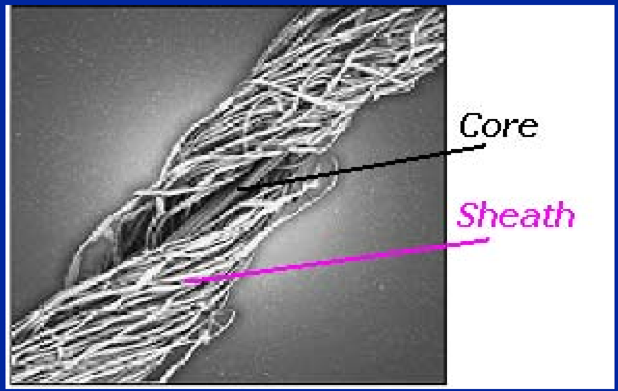
It is also important to keep the tension at a constant value. The yarn produced can be compared with the classical ring spun core spun yarns.

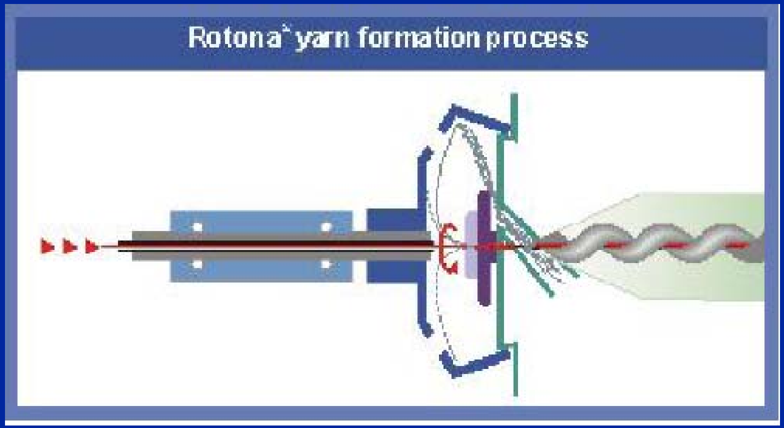
The production speed is up to seven times as ring spinning.

Better elasticity of yarns

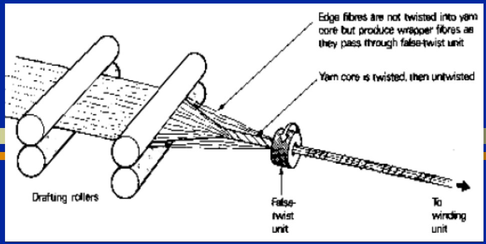
The counts produced Ne. 5- 30

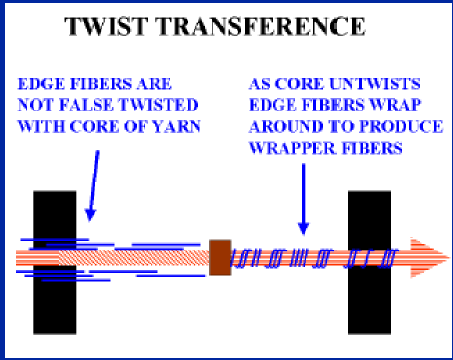
The yarns can be used in sport wears and in rubber industry.





Air-Jet Spinning

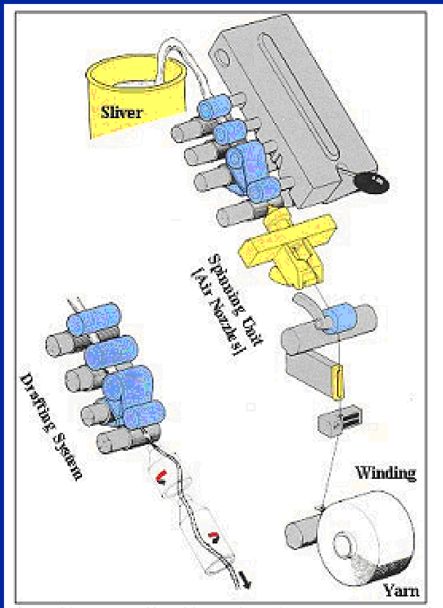




The classical air-jet spinning uses the principle of false-twisting to produce a yarn of uniquely different structure from that of ring or rotor spun yarn. While ring-spinning is characterized by a continuity in the fiber flow, and rotor spinning is characterized by a complete separation of fibers prior to spinning, air-jet spinning exhibits an intermediate feature in which part of the fiber strand flows continuously and another part is separated.

Similar to rotor spinning, the input strand in air-jet spinning is a drawn sliver, which may be carded or combed. Drafting is achieved using multiple zone roller drafting. The consolidation mechanism in air-jet spinning is achieved by blowing out compressed air through air nozzle holes of about 0.4mm diameter to form an air vortex. The air revolves at high speed (more than 3 million rpm). Thus, the rotating element in air-jet spinning is air. This results in a rotation of the fiber bundle at a rate typically ranging from 200,000 to 300,000 rpm.

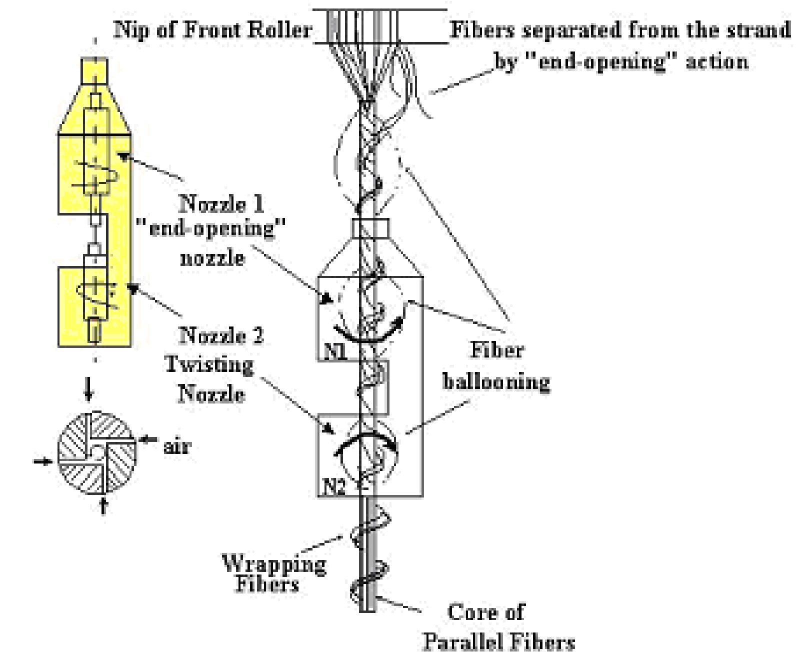
The figures shows the air-jet spinning system produced by Murata. Two air nozzles are used: nozzle 1 may be called the "end-opening" nozzle, and nozzle 2 may be called "the twisting nozzle". These names imply the specific functions of these two nozzles as explained below



Murata Air-Jet Spinning System

The Principle of Air-Jet Spinning

To simplify the principle of the consolidation mechanism, suppose that only nozzle 2 is at work and that air is rotating in a clockwise direction. This action will result in twisting the fibers fed to the nozzle to form a yarn. When the yarn leaves the nozzle, untwisting takes place. Thus, with one air nozzle, a case of pure false twisting is achieved. In the actual machine, another nozzle (nozzle 1) is positioned between the nip of the front roller and nozzle 2, with air rotating in a counterclockwise direction. Thus, the two nozzles apply air rotation in two opposite directions. However, the air in nozzle 2 has a higher rotational speed than nozzle 1 to avoid complete false twisting. The fiber strand, coming out of the delivery roll, forms a spinning triangle similar to that in ring spinning. However, fibers in this triangle are under much less tension than those in ring spinning. In other words, the fibers in the triangle are comparatively loose. The air rotation of the fiber strand in the two nozzles results in ballooning the fiber bundle between the front roller and nozzle 1, and in turning the balloon in nozzle 2. This balloon has no significant tension, which results in some fibers being raised from the bundle surface and move freely. This process is called "the end-opening" action. Thus, the opposite rotation of air in nozzle 1 assists in detaching some fibers from the input strand

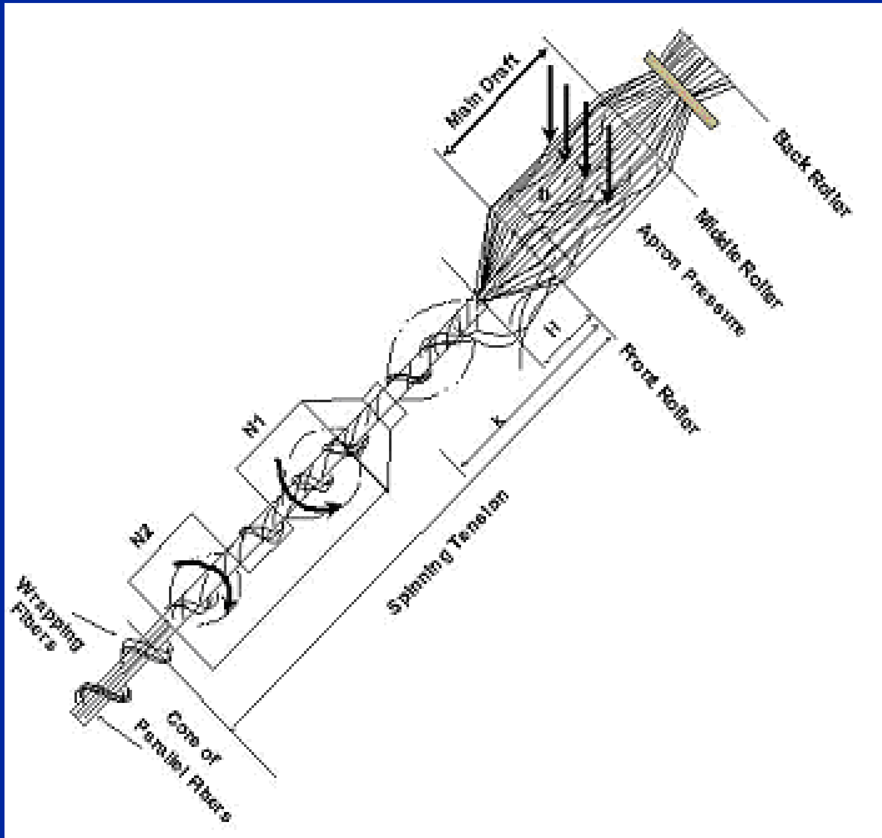


Principle of Air-Jet Spinning

Main Parameters affecting Air Jet Spinning

The main spinning parameters in air-jet spinning are as follows :

- **The main draft ratio ($V_{Front\ Roller}/V_{Second\ or\ Apron\ roller}$); this varies from 15 to 50, but generally runs from 30 to 40.**
- **Distance between the first nozzle and the nip of the front roller, k.**
- **The feed ratio (($V_{Front\ Roller}/V_{Delivery}$); this ranges from 0.98 to 0.99**
- **Spinning speed (up to 300 m/min)**
- **Air pressure in nozzle 1 (typically, 2-5 kg_f/cm^2)**
- **Air pressure in nozzle 2 (typically, 2-5 kg_f/cm^2)**



Parameters of Air-Jet Spinning

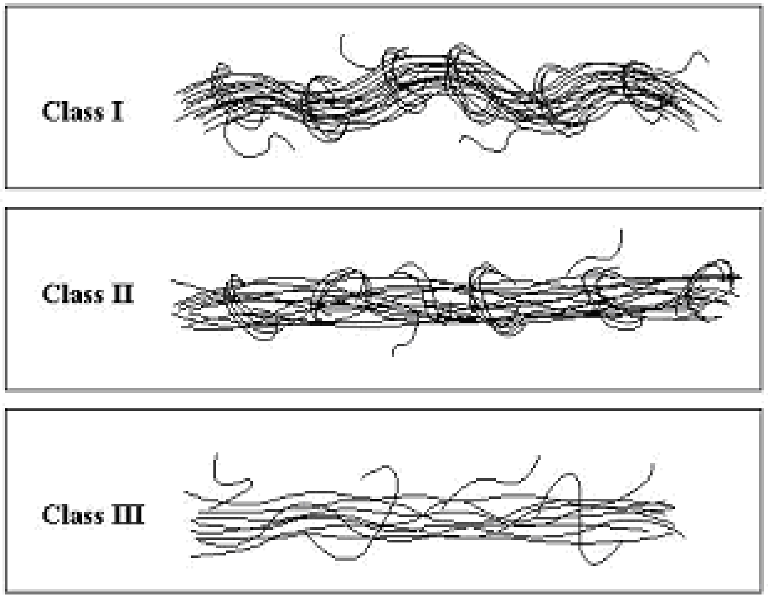
Effect of Spinning Parameters on Yarn Structure I

Many investigators examined the structure of air-jet spun yarns (e.g. Grosberg et al, 1987, Lawrence et al, 1991, Nakahara, 1984 and 1986, Chasmawala et al, 1990, Krause et al 1990, and El Mogahzy, 1994). Using an air-jet experimental unit, Lawrence divided air-jet yarn structures into three main classes:

•Class I: a twistless core, which at times is crimped, but wrapped uniformly by a thin fiber ribbon with a uniform helix angle (40-45^o)

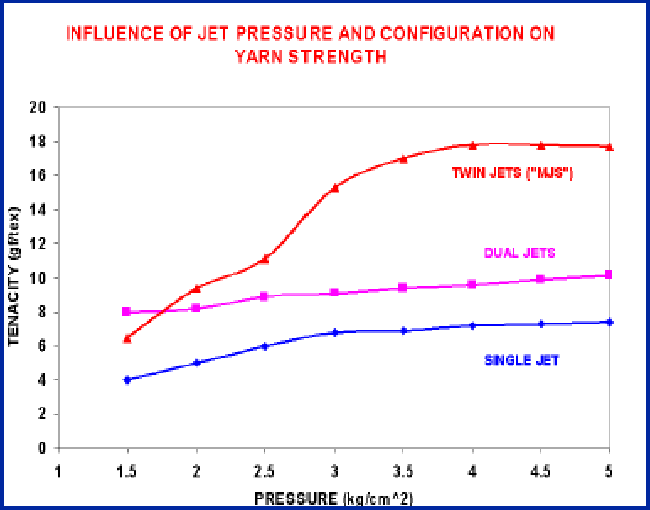
•Class II: a twistless core randomly wrapped by fibers, in a singular state and in groups, showing Z and S directions of wrap with differing helix angles (45-90^o). Core crimp is not as pronounced as in Class I.

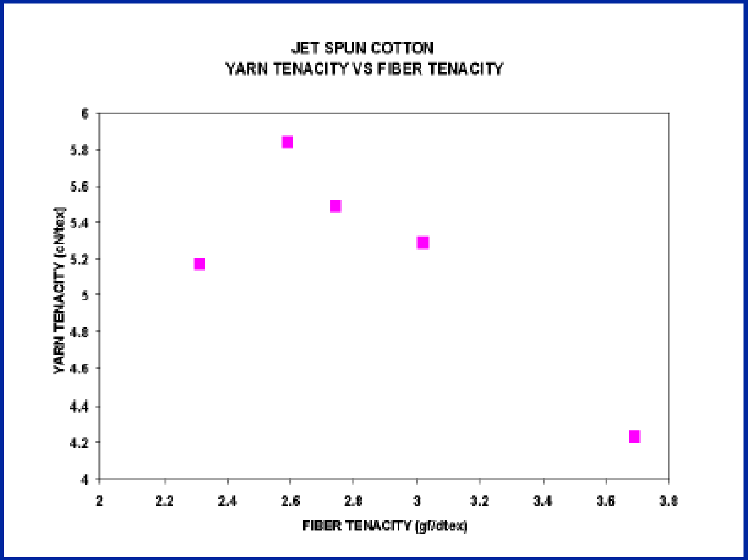
•Class III: unwrapped sections of yarn core, at times having residual twist

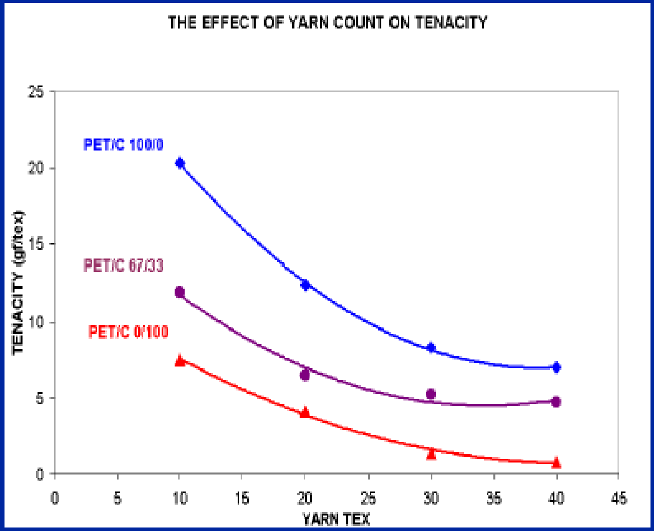


Structures of Air-Jet Spun Yarn Proposed by Lawrence et al.

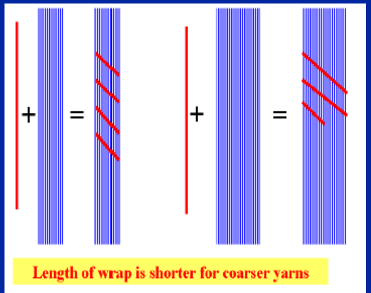
Effect of Spinning Parameters on Yarn Structure II

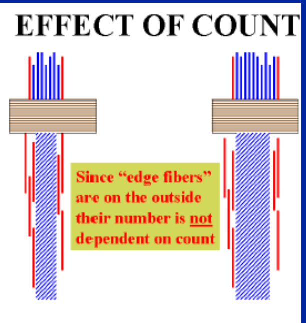




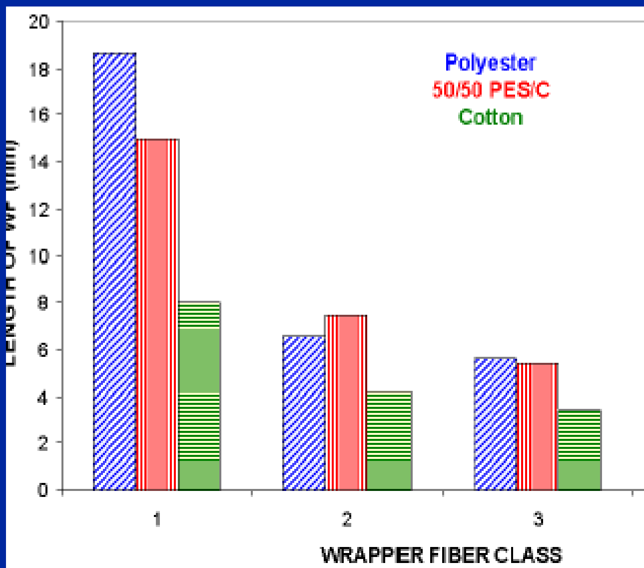


jet spinning seems to be sensitive to the number of fibers in the yarns cross section. Edge fibers ultimately produce wrapper fibers, which in turn promote yarn strength.

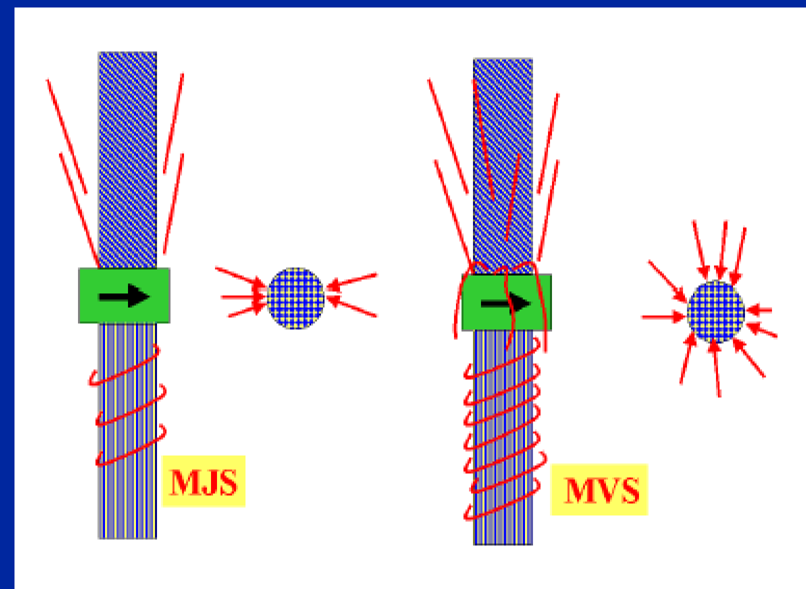




Effect of Spinning Parameters on Yarn Structure III



INFLUENCE OF FIBER TYPE ON LENGTH OF WRAPPER FIBERS

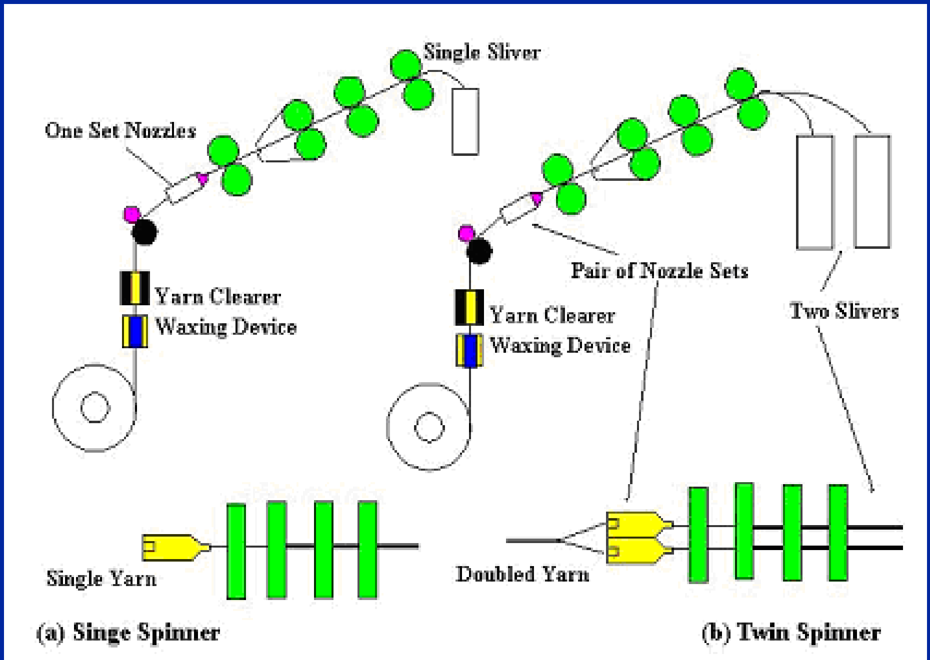


changing the system from ”two dimensional” to “three dimensional” offers the possibility of dramatically increasing the number of edge fibers and hence the number of wrapper fibers. This scenario is shown schematically

Developments in Air-Jet Spinning

Air-jet spinning machinery may be divided into two main types: single end spinners, and twin spinners

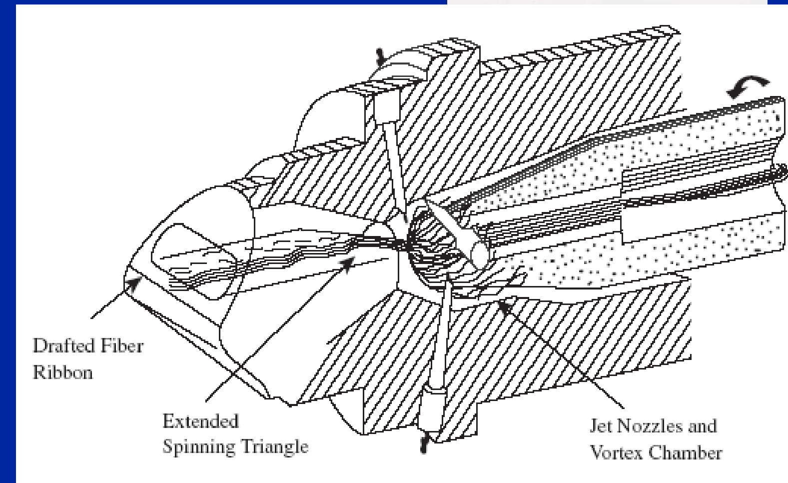
In the twin-spinner, two slivers are fed to the same drafting system where they are drafted. The drafted strands are then fed to two different spinning units (air nozzles) to produce two single yarns. These two yarns are then doubled together onto a take-up package suitable for two-for-one twisting system. The twin spinner is therefore suitable for applications where plied yarns are required. In comparison with ring spinning, the twin spinner eliminates roving, winding, and doubling machinery.



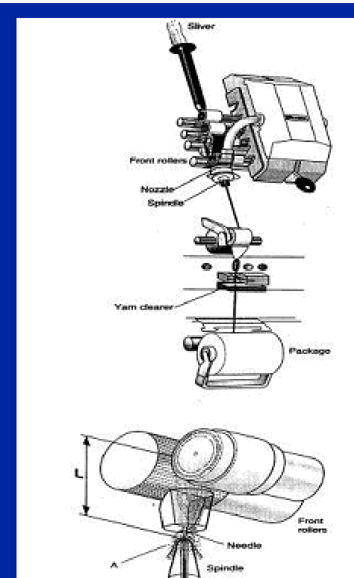
Schematics of MJS Single & Twin Spinners

Murata Vortex Spinning (MVS)

The Murata Vortex Spinning (MVS) system was introduced in 1998 under the commercial name “MVS851”. This system uses the principle of air vortex to produce a yarn similar in structure to that of the ring-spun yarn. The idea of this development is to improve two important features of the jet-spinning system: (i) the number of wrapper fibers, and (ii) the length of wrapper fibers. Accordingly, MVS should be considered as an inevitable and natural evolution of the MJS system. The driving force of MVS development was to produce 100% cotton yarns on jet spinning .



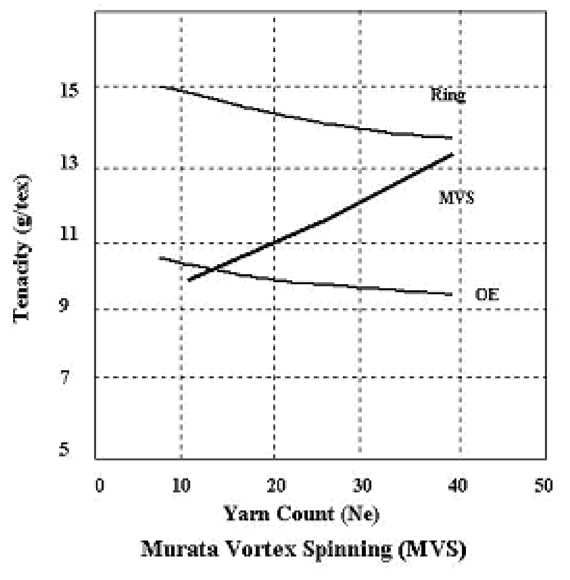
As in the conventional MJS, a finished drawn sliver is directly fed to a roller drafting system, similar to that used on the MJS system. The drafted fibers are passed through an air-jet nozzle and hollow spindle. Fibers exiting the nip of the front rollers are sucked into a spiral orifice at the entrance of the air nozzle, and they are then held together more firmly as they move towards the tip of a needle protruding from the orifice. At this stage, the force of the air stream twists the fibers. This twisting motion tends to flow upwards. The needle protruding from the orifice prevents this upward propagation (twist penetration). Therefore, the upper portions of some fibers are separated from the nip point of the front rollers but they are kept open.



Murata Vortex Spinning (MVS®)

Murata Vortex Spinning (MVS)

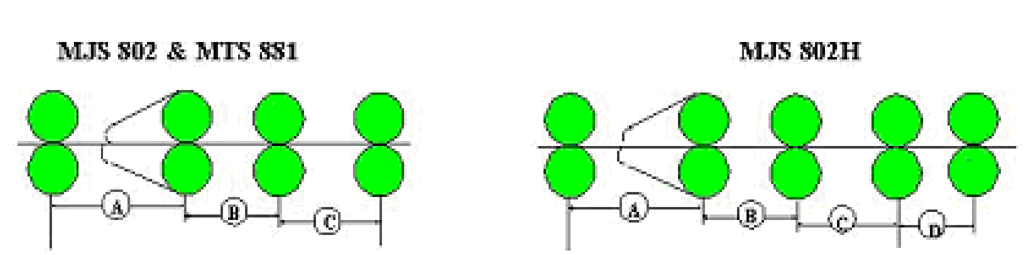
After the fibers have passed through the orifice, the upper portions of the fibers begin to expand due to the whirling force of the jet air stream and they twine over the hollow spindle. The fibers twined over the spindle are whirled around the fiber core and made into MVS yarn as they are drawn into the hollow spindle. The finished yarn is wound onto a package after it is cleared using defect detector. Thus, the consolidation of fibers is achieved by applying a rapidly spiraling flow of compressed air at a non-rotating spindle tip in the air nozzle.



One of the spinning parameters that influence the physical characteristics of MVS yarn is the distance between the nip of the front roller and the tip of the spindle (distance L in Figure 9.35). The larger this distance is, the more the “upper portion open” fibers, resulting in a yarn of characteristics similar to those of truly twisted yarns. If the distance is too large, the waste fiber rate will also be extremely large. Murata suggests a distance that is slightly shorter than the average length of fibers.

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

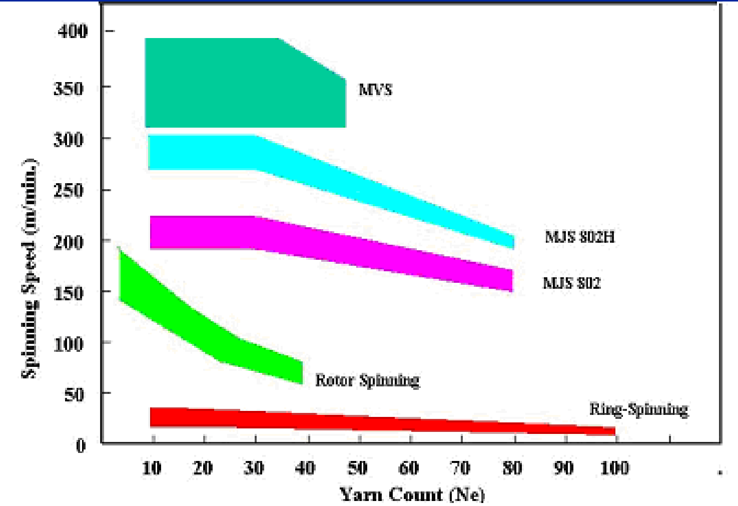
Production of Different Yarns



A	B	C	Raw Material
37mm 44 mm	34-36mm 39-43mm	34-36mm 39-43mm	100% Cotton FL = 1.5 inch Synthetics & Cotton/Synth blends
56mm	52-54mm		FL = 2 inch/Synthetics

A	B	C	D	Raw Material
34 44	32-36 39-43	34-36 39-43	34-36 39-43	100% Cotton FL = 1.5 inch Synthetics & Cotton/Synth blends
56	52-54	52-56		FL = 2 inch/Synthetics

Draft Settings in MJS 802, 802H & MTS 881 Machinery

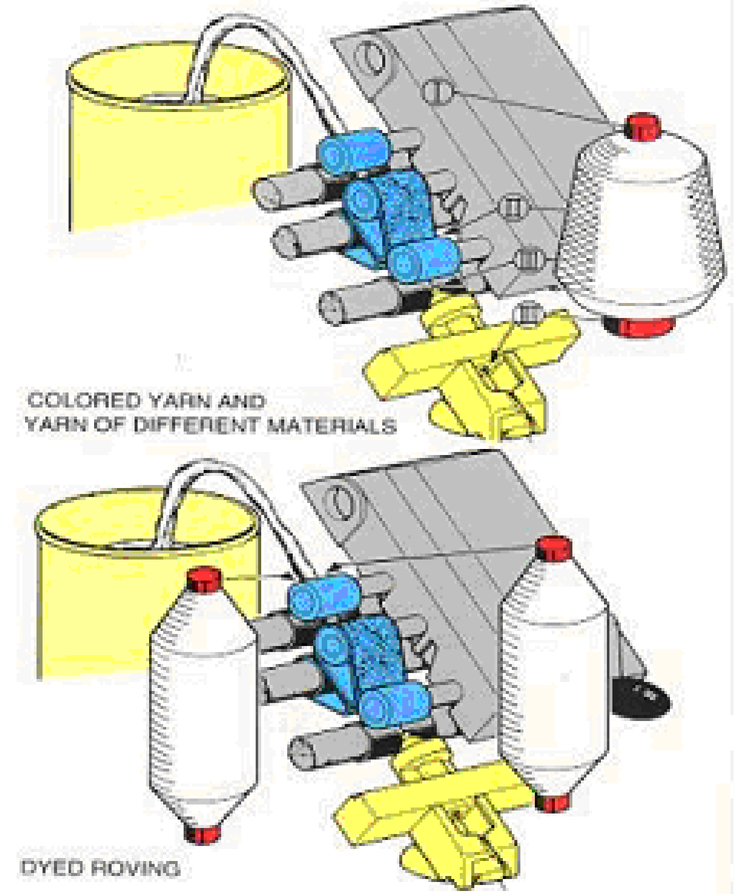


The Relationship Between Spinning Speed and Yarn Count

As shown in Figure 9.32, both MJS 802 and MTS 881 utilize a 4/4 drafting system with double apron. MJS 802 H utilizes a 5/5 drafting system. The 5/5 drafting system is believed to have a better control on the sliver through a gradual zonal draft. It enables high draft spinning of up to 300. According to Murata, this results in about 33% increase in the production rate (kg/hr) and up to 50% increase in spinning speed (m/min.). In this regard, we should point out that the spinning speed in air-jet spinning depends largely on the yarn count to be produced

Special Core Yarn

Specialty yarns may be made from continuous filaments (e.g. polyester) in the core surrounded with a wrapper of cotton staple fibers. It can also be made from fibers of different colors to produce special effects. Murata designed a number of systems that are suitable for producing such type of yarns. For example, the SPUNDEX® core yarn device permits drawing of elastic polyurethane fibers 4 to 6 times using positive feed rollers and winding short fibers (e.g. 100% cotton) around the core as the sheath. In this system the two types of fibers follow two different pathways before they are entered together to the nip of the front roller.



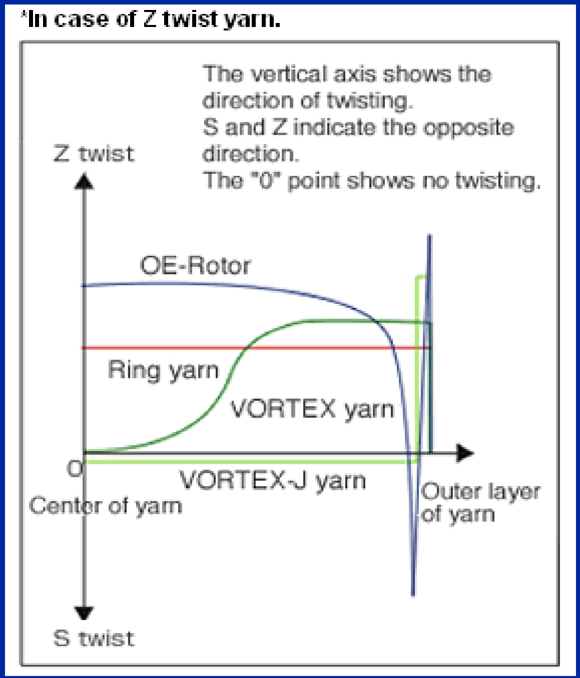
Specialty Air-Jet Spun yarns

Yarn Structure I

In VORTEX spinning, the tip of the fiber is focused to the center of the yarn by the vortex of compressed air so that the center of the yarn is always made straight without twisted. The other tip forms the outer layer that twines another fiber. This technology is not applied to any limited material, but produces the VORTEX yarn with a unique structure through VORTEX spinning regardless of materials.

Twist structure of VORTEX yarn

The figure on the right shows vertically the tightness of twisting, and Z-twist and S-twist indicate the directions of twisting centering on "0."
The horizontal axis in the graph shows the distance from the center in a cross section of the yarn.
The image chart of each type of yarn shows the yarn-twisting structure seen from the side.

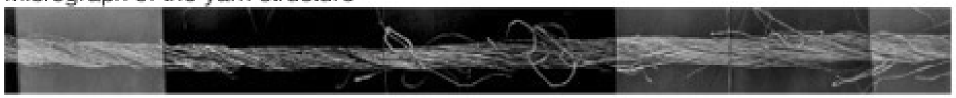


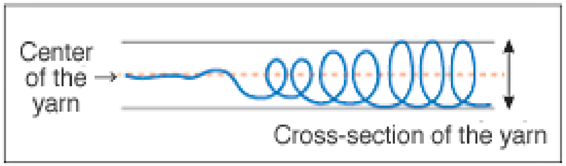
Yarn Structure II

VORTEX yarn

The center of the yarn is not twisted. Twisting is given toward the outer side of the yarn, twisting at the center of the yarn is loose, while the outer side is fully twisted.

Micrograph of the yarn structure

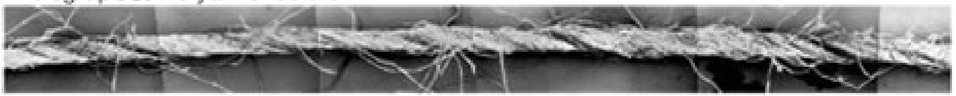


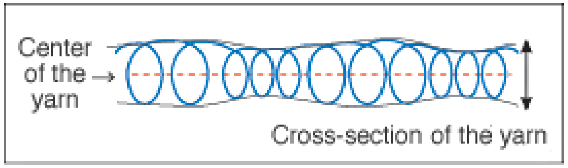


Ring yarn

There is no non-twisted section, twists of a certain level are given to the entire yarn from the center to the surface of the yarn. The yarn thickness is uneven. Twisting is concentrated at the thinner sections, while twisting is loose at the thicker sections and hairiness tends to come out.

Micrograph of the yarn structure



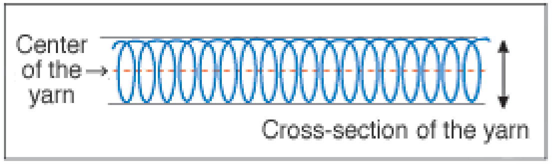


Yarn Structure III

OE-Rotor yarn

All fibers are twisted from the center to the outer side.
For fibers near the surface of the yarn, twisting is uneven, and sometimes, twisting is made in the opposite direction from around the center.

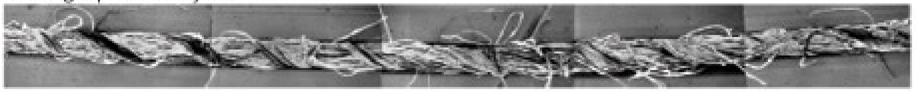
Micrograph of the yarn structure

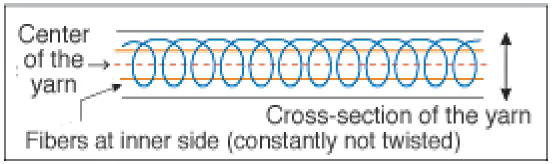


VORTEX-J yarn

Most of fibers are not twisted, but some fibers near the surface bundle those of inner side.
The thickness of the yarn is stable, and strength and angle of twisting of bundling fiber are even.

Micrograph of the yarn structure

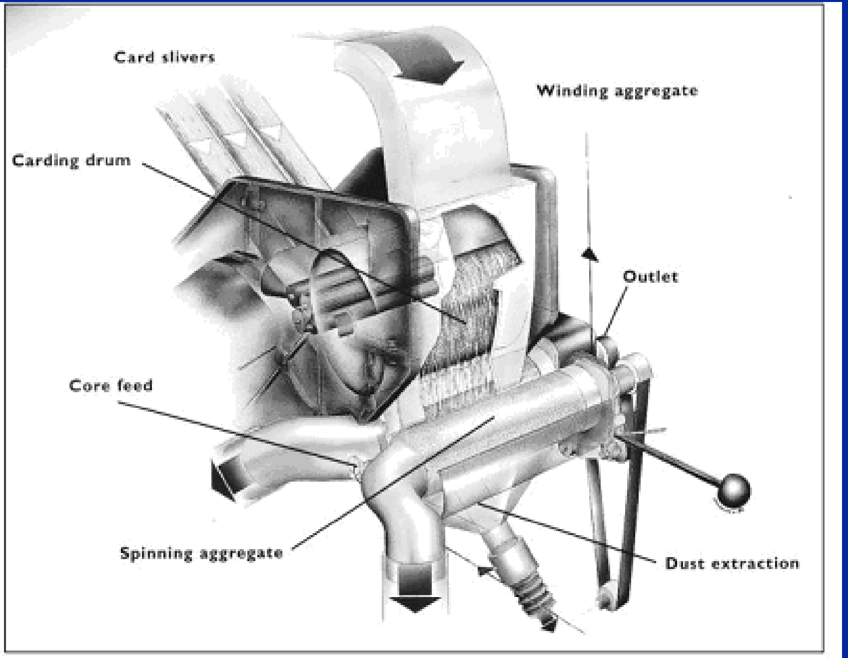




Friction Spinning (Dref 2)

This system can use a wide range of raw material from reclaimed waste fibers to high-tech specialty fibers and from natural staple fibers to man-made continuous filaments. The end products that can be made from friction-spun yarns are numerous. These include cleaning rags, mops, secondary carpet backing for tufted carpets, asbestos substitutes for friction linings, packing, gaskets, upholstery, recycled fibers outerwear, high-tenacity fire resistant protective clothing, and composites for the aviation, and automotive components.

In DREF 2, a card or drawn sliver is fed to an opening roller (or a carding drum) for individualization or separation of fibers. An air current carries the fibers from the card drum to the nip of the friction drums, where the fibers are twisted together to form a yarn. Take-up rollers pull the yarn out of the twisting zone to the winding unit. DREF 2 can handle a wide range of raw material including natural, man-made, recycled, blended or industrial (aramids, glass and carbon) fibers

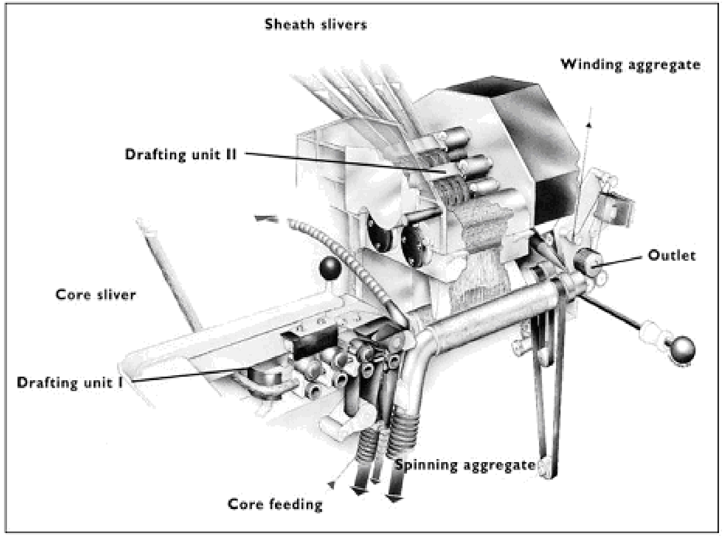


DREF2 Friction Spinning

. The total feed weight can be as high as 30 ktex or 420 grains/yd. For example, 6 slivers each of 70 grains/yd can be fed to the carding unit to produce a yarn. The fiber fineness may range from 1.7 to 17 dtex (1.5-15 denier). Staple length may vary from 0.8 to 6 inch. Feeding, say, a filament as a core through a special core-feeding system and using the fibers coming out of the opening roll as a sheath can produce a core/sheath yarn. The yarn produced on DREF2 is on the coarse side with a typical range from 0.15's to 6's (4000 -100 tex). The delivery speed may reach up to 300 m/min depending on fiber type and yarn count.

Friction Spinning (Dref 3)

DREF 3 has the same flexibility of the DREF 2 in handling a wide range of raw material. The core fiber from the first drafting unit can be almost any synthetic fiber including industrial fibers (e.g. aramid and carbon); these fibers can be pure or blended. Cotton can be used if it is blended with synthetic fiber. The second drafting unit uses the same fibers with the addition that it can use carded cotton sliver. Filaments that can be used include metallic wire, glass filament, elastomeric filament, monofilament, textured filament, and high tenacity filament. The sliver weight range for the drafting units is 2.5-3.5 ktex (35-50 gr/yd) for each sliver. The fiber fineness may range from 0.6 to 6.7 dtex (0.5-6.0 denier). The staple length is limited to 1.25-2.5 inch. DREF 3 can produce yarns in a count range from 0.18's to 18's (667-33 tex). The delivery speed may reach up to 300 m/min depending on fiber type and yarn count.

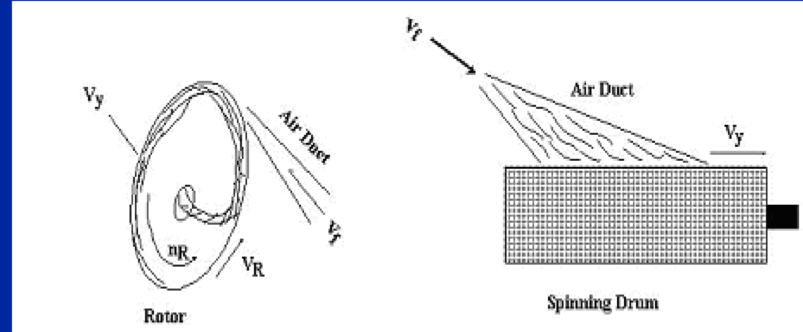


DREF3 Friction Spinning

As in the conventional MJS, a finished drawn sliver is directly fed to a roller drafting system, similar to that used on the MJS system. The drafted fibers are passed through an air-jet nozzle and hollow spindle. Fibers exiting the nip of the front rollers are sucked into a spiral orifice at the entrance of the air nozzle, and they are then held together more firmly as they move towards the tip of a needle protruding from the orifice. At this stage, the force of the air stream twists the fibers. This twisting motion tends to flow upwards. The needle protruding from the orifice prevents this upward propagation (twist penetration). Therefore, the upper portions of some fibers are separated from the nip point of the front rollers but they are kept open. After the fibers have passed through the orifice, the upper portions of the fibers begin to expand due to the whirling force of the jet air stream and they twine over the hollow spindle. The fibers twined over the spindle are whirled around the fiber core and made into MVS yarn as they are drawn into the hollow spindle. The finished yarn is wound onto a package after it is cleared using defect detector. Thus, the consolidation of fibers is achieved by applying a rapidly spiraling flow of compressed air at a non-rotating spindle tip in the air nozzle

Yarn Forming (Fiber Landing)

The way fibers are deposited or landed on the friction drum largely determines the structure of friction spun yarns. Fiber landing on the friction drum (the consolidation unit) is quite different from fiber landing onto the rotor in rotor spinning. This difference is illustrated in Figure 9.39. Both systems use an air duct to transfer the fibers from the mechanical drafting unit (opening roll) to the spinning unit. However, the landing pattern is substantially different. In rotor spinning, individual fibers flowing through the air duct are accelerated as they approach the rotor. The level of twist (the rotational speed of the rotor) and the spinning tension positively control the ratio between the number of fibers per yarn cross-section and the number of fibers approaching the rotor. The doubling effect resulting from the fiber condensation in the rotor inside surface, and the existence of centrifugal force on the fiber mass assists in improving both the uniformity and the fiber packing in the yarn.



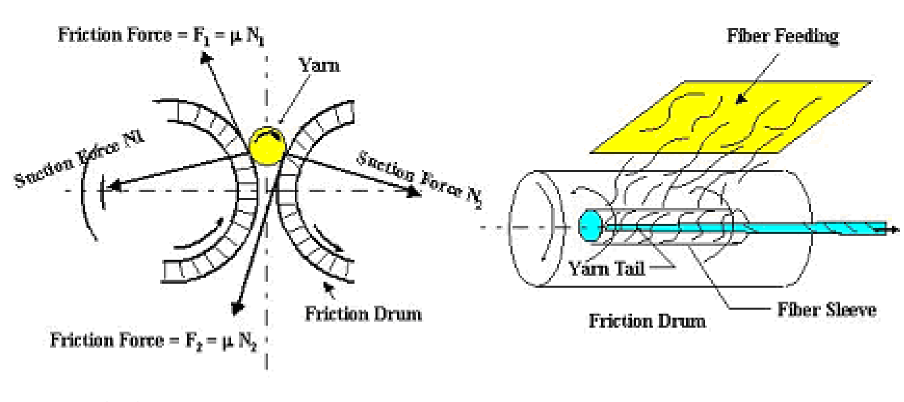
(a) Fiber Landing in Rotor Spinning	(b) Fiber Landing in Friction Spinning
- Fibers are accelerated through the air duct. - Fibers are drafted when joining the fiber assembly in the rotor. - Doubling effect	- Fibers are slowed down. - Fibers are compressed when joining the fiber assembly on the drum. - Irregular doubling and positioning of fibers in the yarn.

Comparison of Fiber Landing in Rotor and Friction Spinning

In friction spinning, fibers coming from the opening unit approach the spinning unit at a higher speed than the outlet speed of the yarn. This results in a compressive action as the fibers touch the nip between the friction drums. This compressive action results in a great deal of fiber disorientation or fiber looping.

Twisting Mechanism

As indicated earlier, the twisting mechanism in friction spinning is achieved by feeding the fibers into the nip of two spinning (friction) drums, which rotate them to form the yarn. The resulting twist, however, does not correspond to the ratio of yarn diameter to drum diameter because of the slippage effect, which can lead to a loss of up to 60%. The problem associated with fiber landing discussed above adds to the problem of twist loss by introducing a great deal of twist variability.



Principle of Twisting in Friction Spinning

In the absence of a significant spinning tension during twisting, it becomes critically important to control the fibers as they are rotated in the twisting zone. This control is achieved by applying equal frictional forces on the two contact areas between the fibers and the spinning drums. The yarn/drum friction force is determined by the classical Amontons law, $F = \mu N$, in which μ is the coefficient of friction between the fiber surface and the drum surface, and N is the normal force applied on the area of yarn/drum contact. The normal force is exerted by the air evacuation, which results in fastening the fibers to the drum surface during twisting. The use of two friction drums allows equal normal force application on the two contact areas. In addition, the friction coefficients of the two friction drums should be of equal values.

Advantages of Dref

Advantages of spinning system DREF:

- relative simplicity
- low rotation speed of twisting device - 3500 rpm
- count range of supply slivers –of 5- 15ktex card sliver, 3-7ktex drafted sliver
- high delivery speed (280m/min)
- spinning with low yarn breakage causes by low tensile force during yarn taking-up (without overcoming of centrifugal force)
- staple length up to: 120mm
- big cross-wound bobbins of 4,0 – 8,0 kg weigh.
- possibility of production of core and fancy yarns

Disadvantages:

- only for coarse yarns – carpet, furniture industry
- lower tenacity in comparison with classical spun yarns due to faulty parallelization of fibres in yarn - fibres in axis are twisted-off, on the yarn surface the twist is slighter

Yarn Irregularity and Faults

•Yarn irregularity affect twist distribution in yarn (thick places have less twist)

•yarn irregularity mainly affect fabric appearance and many other properties.Uster evenness tester is the most popular instrument used for evaluation of irregularity characteristics.

•Irregularity can be defined as the continuous variation in mass per unit length and expressed as coefficient of variation CV, where faults are discrete function and are expressed as number of faults per unit length. Faults may occur frequently and known as imperfections (thick, thin places and neps), or occur seldom. These have longer length (slubs, fly, piecing, long thick or thin places, snarls and loops …)

•Analysis of yarn irregularity can be provided on the base of descriptive statistics methods (CV% values) or on the basis of time series and signal analysis principles.

Theoretical background:

Martindale's theory:

General assumptions: Fibers form fibrous sliver

- **are straight and parallel to sliver axis**
- **have same length and density**
- **are positioned along the sliver INDIVIDUALLY and randomly**

Ideal or Limit irregularity of a fiber assembly CV_{limit}:

$$CV_{\lim[\%]} = \frac{100}{\sqrt{n}}\sqrt{1+0.0001CV_{t[\%]}^{2}}$$

Where CV_t is the coefficient of variation of fiber fineness, and n number of fibers in cross section

$$CV_{\lim[\%]} = \frac{100}{\sqrt{n}}\sqrt{1+0.0004CV_{d[\%]}^{2}}$$

And CV_d is the coefficient of variation of fiber diameter.

Theoretical background:

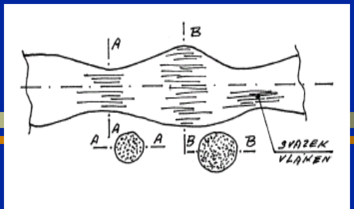
• **<u>Huberty's index of irregularity:</u>**

$$I = CV_{\mathrm{eff}} / CV_{\mathrm{lim}}$$

CV_{eff} measured (actual) value of unevenness

CV_{lim} calculated ("limit") value of unevenness

Theoretical background:

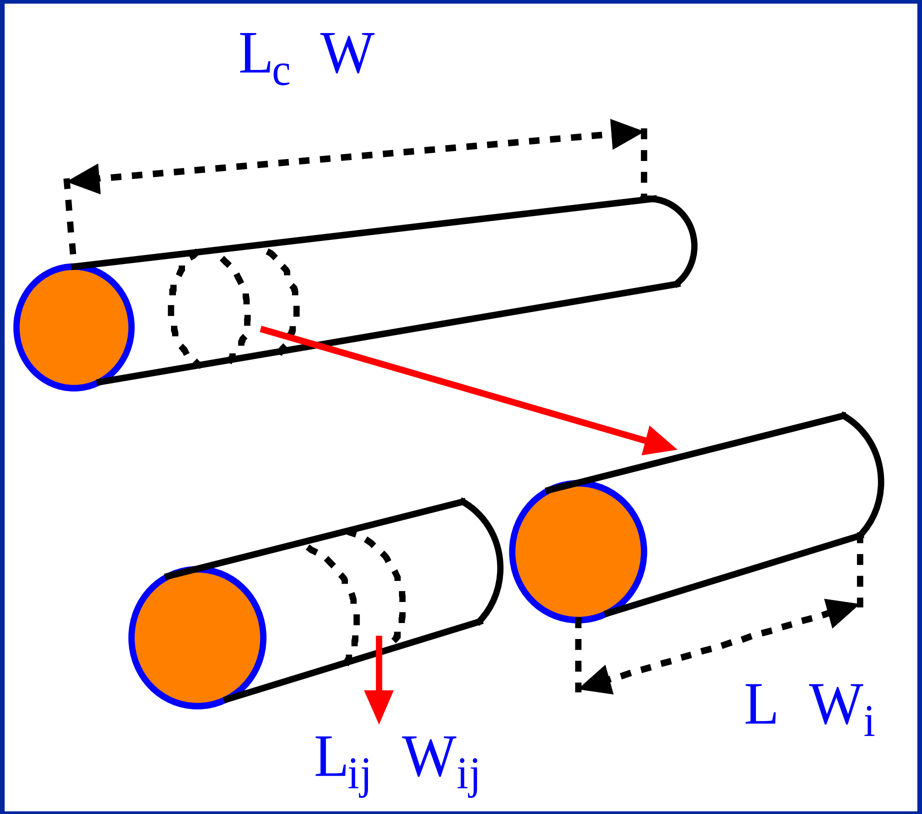


Cutting and weighting

Total length L_c, divided to N portions.In each portion of length L are created local elements of length L_{ij} .

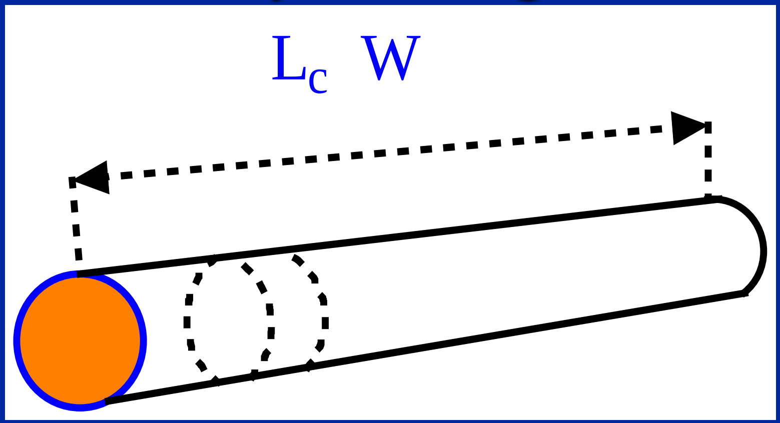
Each portions and elements are weighted.

Weights are denoted W, W_i W_{ij}

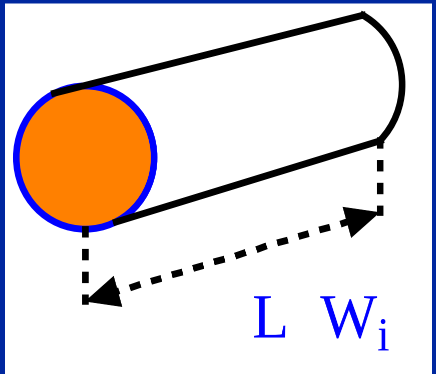


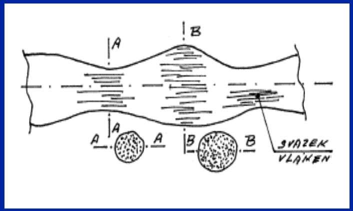
Theoretical background:

- For total yarn length



Variance between portions





$$L_c = \sum_i L_i$$

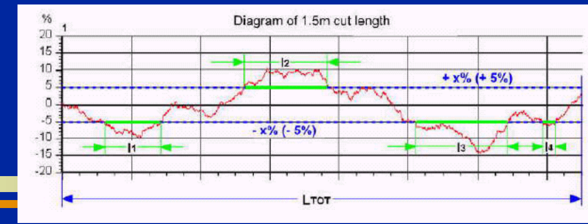
$$N = L_c / L$$

$$W = \sum_i W_i$$

$$s_B^2(L) = \frac{1}{N}\sum_{i=1}^{N}[W_i - \overline{W}(L)]^2$$

$$\overline{W}(L) = \frac{1}{N}\sum_{i=1}^{N} W_i$$

Theoretical background:



Variances

Total variance division

$$s_c^2 = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{1}{N_i}\sum_{j=1}^{N_i}[W_{ij}-\overline{W}]^2\right)$$

$$\frac{1}{N_i}\sum_{j=1}^{N_i}[W_{ij}-\overline{W}]^2 = \frac{1}{N_i}\sum_{j=1}^{N_i}[W_{ij}-\overline{W_i}+\overline{W_i}-\overline{W}]^2 = s_{Vi}^2+(\overline{W_i}-\overline{W})^2$$

$$\frac{1}{N}\sum_{i=1}^{N}[s_{Vi}^2+(\overline{W_i}-\overline{W})^2] = \frac{1}{N}\sum_{i=1}^{N}s_{Vi}^2+s_B^2 = s_V^2+s_B^2$$

$$s_V^2 = \frac{1}{N}\sum_{i=1}^{N}s_{Vi}^2$$

Variance within portion

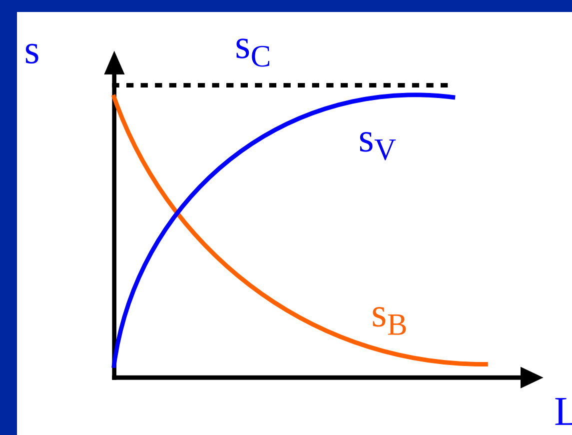
Total variance is sum of

external (between portions)

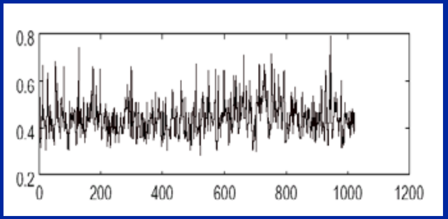
and **internal** (within portions)

Variances

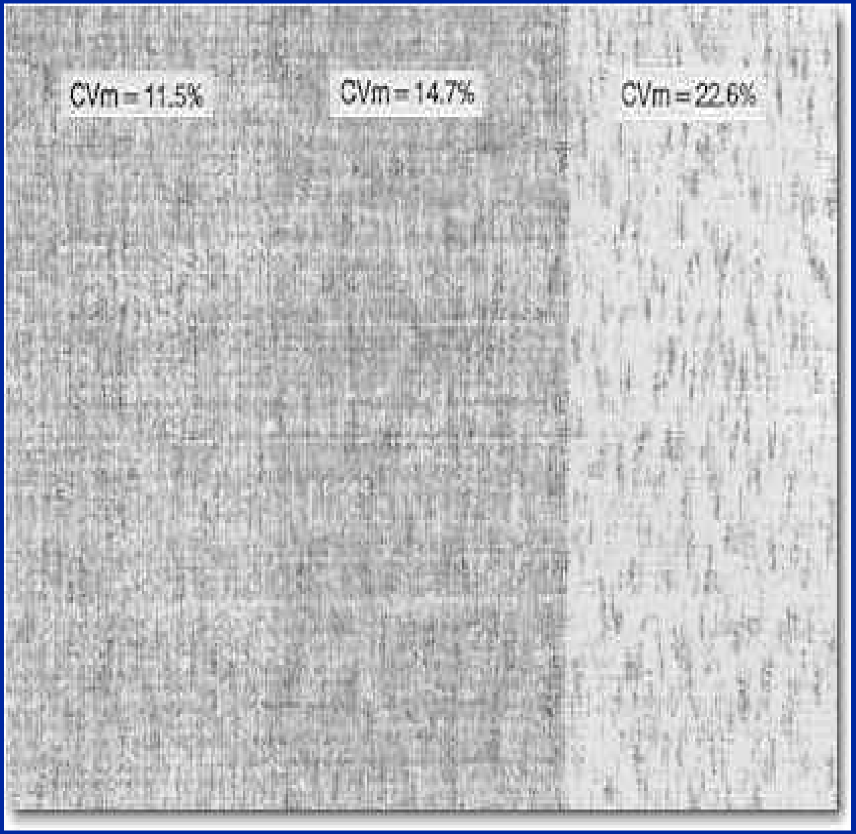
$$s_C^2 = s_V^2(L)+s_B^2(L)$$



Mass unevenness

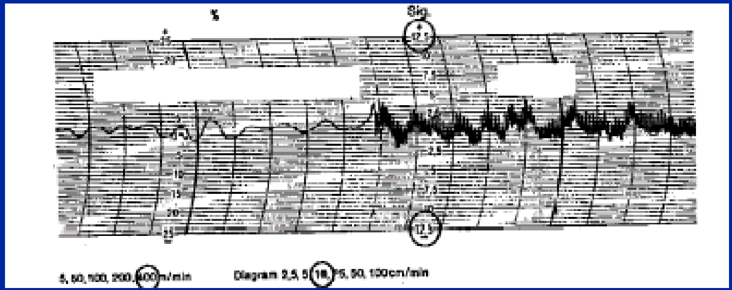


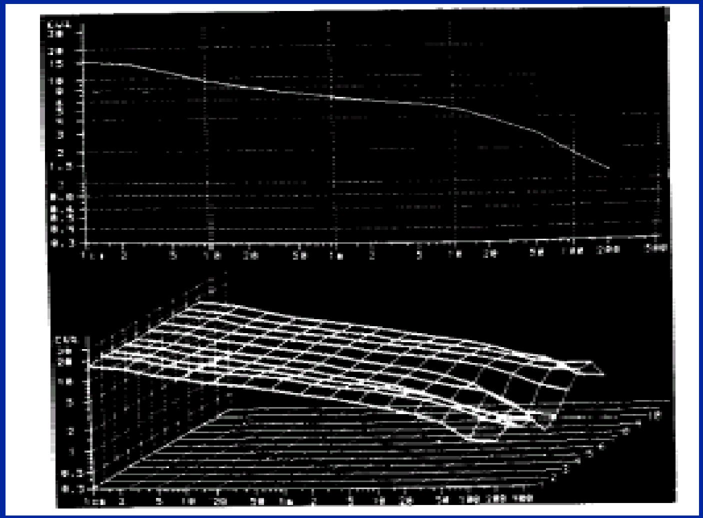
1. Measurement
2. Definition of mass unevenness CV
3. Limit unevenness
3. Interpretation of CV
4. Statistical analysis of CV

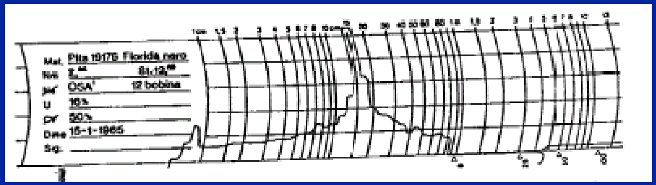


Measurements of Mass unevenness

- **Normal test**
- **Inert test** (larger cut lengths – virtual extension of electrodes length)
- Modern apparatus: – **variance length curve**. $CV_B(L)$ vs. L.
- **Deviation rate curve**

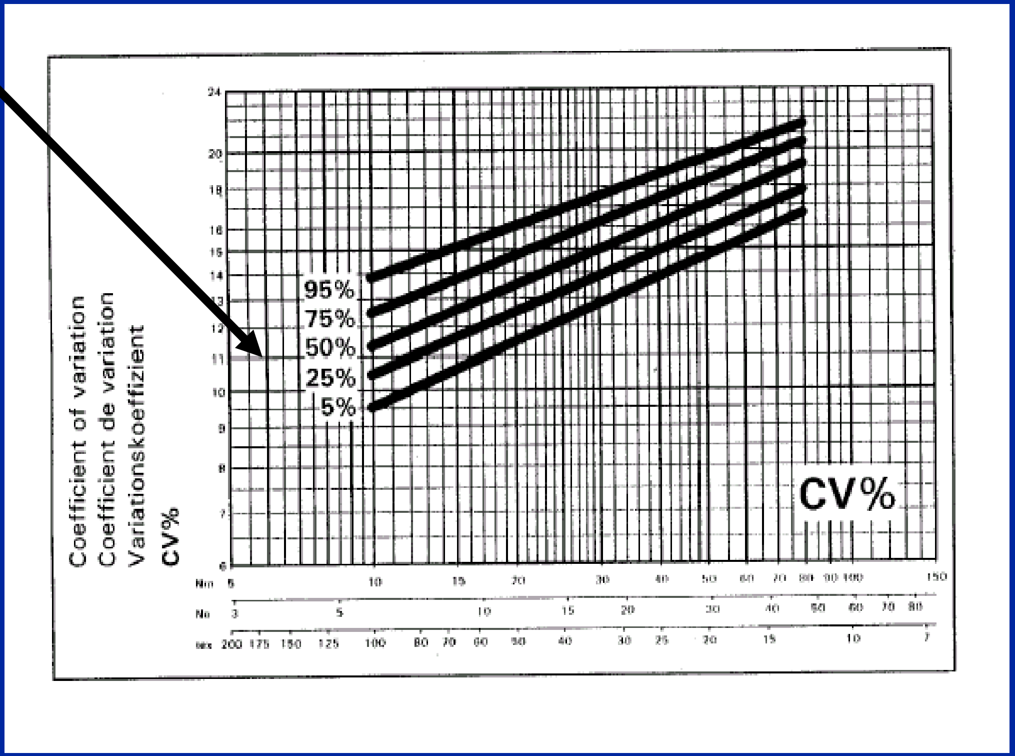






Uster Statistics

Cumulative frequency (portion of companies producing yarns with CV less or equal to given value (here 50%)



Deviation rate I

The approach based on the percentage of mass deviation exceeding or falls below a certain limit is used for characterization of yarn unevenness.
The deviation rate *DR(b)* expresses a portion of the length of yarn that is not within the limits

The *DR(b)* has the form:

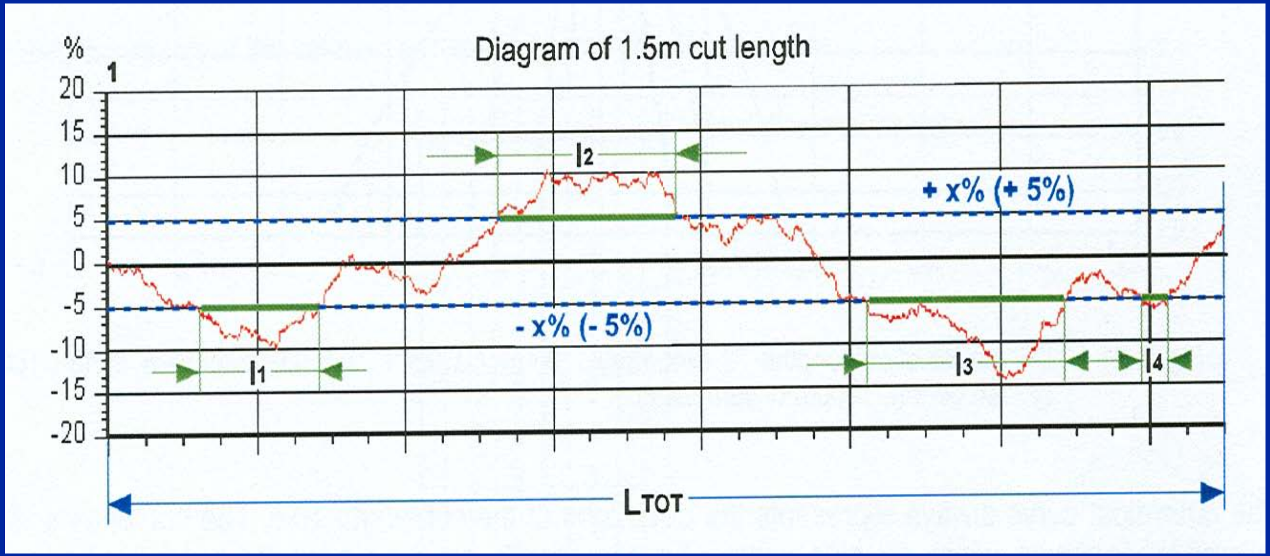
$$DR(b) = \frac{\sum_{i=1}^{N} D(i)}{N} * 100$$

$$D(i) = 0 \quad \text{if } \bar{y} - b < y(i) < \bar{y} + b$$

$$D(i) = 1 \quad \text{elsewhere}$$

The DR - plot is then dependence of *DR(b)* on *b*

Deviation rate II



The *DR(b)* is closely connected with probability for which is random process *y(i)* exceeding of value *b*

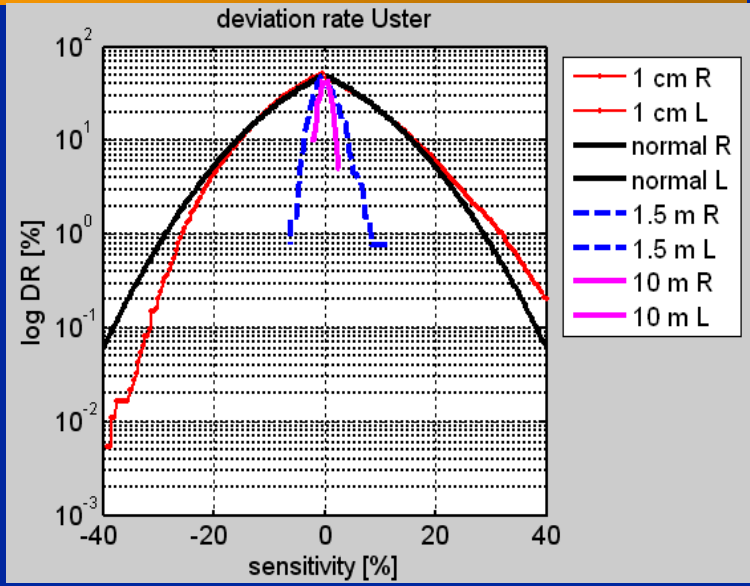
Deviation rate III

Alternatively, the deviation rate

DRR(b) **corresponding to the portion of the length**

of yarn that is above limit and deviation rate ***DRL(b)***

expressing a portion of the length of yarn that is below limit can be computed. From ***DRR(b)*** **and** ***DRL(b)*** **the** **<u>*DR* -mass histogram</u>** **in logarithmic scale of** ***DR*** **can be created. Into this graph the histogram of normal distribution is superimposed.**



This graph is useful for comparison of unevenness at various cut lengths ***L*****. Standard selection is** ***L = 0.01*** **m,** ***1.5*** **m and** ***10*** **m.**

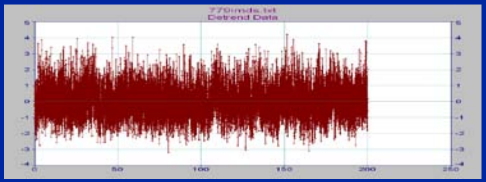
Basic definitions of Time Series

•*A time series* is a sequence of observations taken sequentially in time. The nature of the dependence among observations of a time series is of considerable practical interest.

•The time series analysis is concerned with techniques for the analysis of this dependence.

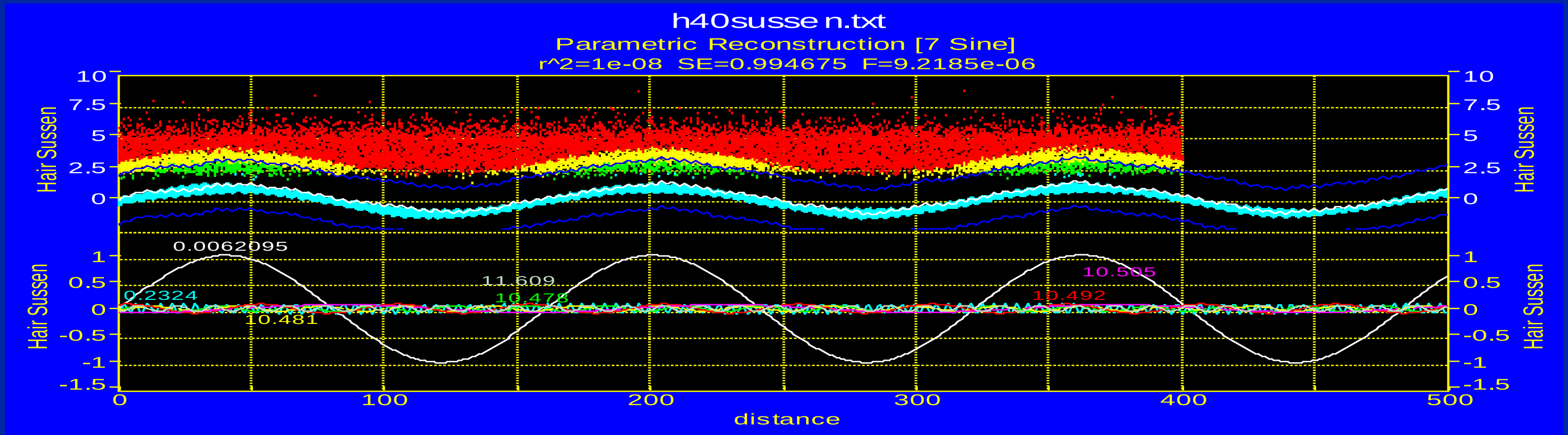
•Stationary model assumes that the process remains in *equilibrium* about a *constant mean level.* The random process is strictly stationary if all statistical characteristics and distributions are independent on ensemble location.

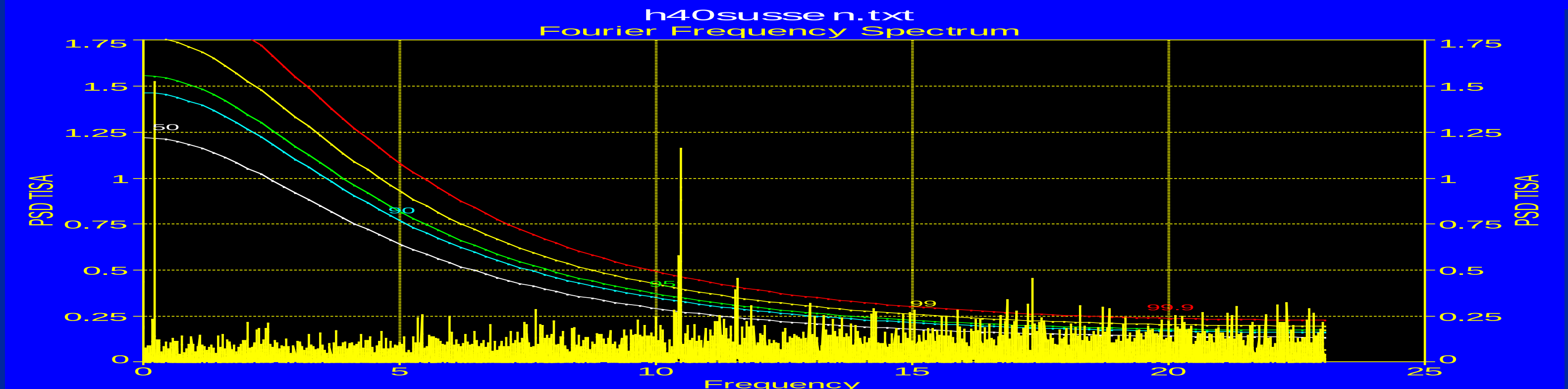
•Many tests such as *nonparametric test, run test, variability (difference test), cumulative periodogram construction* are provided to explore the stationarity of the process.



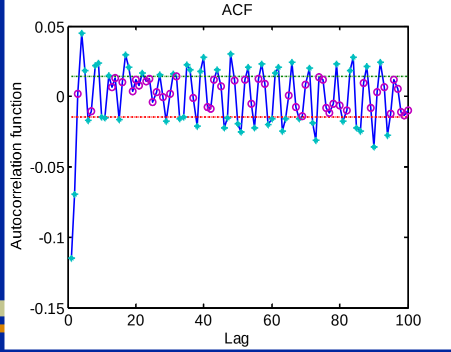
SPECTROGRAPH

The Fast Fourier Transformation is used to transform from time domain to frequency domain and back again is based on Fourier transform and its inverse. There are many types of spectrum analysis, PSD, Amplitude spectrum, Auto regressive frequency spectrum, moving average frequency spectrum, ARMA freq.





Autocorrelation R(1)

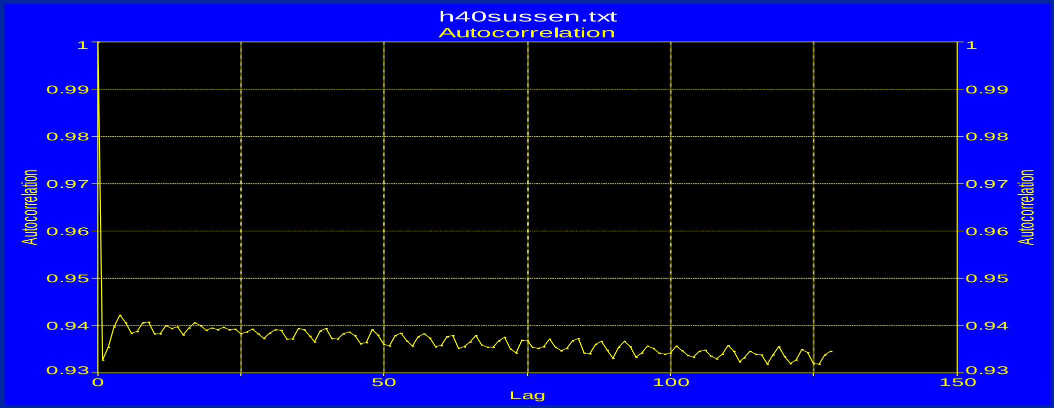


Autocorrelation coefficient of first order R(1) can be evaluated as

$$R(1) = \frac{\sum_{j}^{N-1} (y(j) - \bar{y})*(y(j+1) - \bar{y})}{[s^2(N-1)]}$$

Roughly, if R(1) is in interval

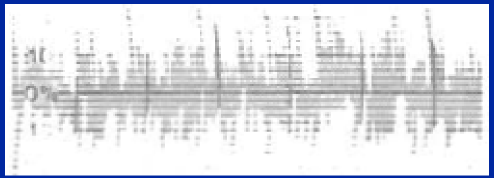
$$-2/\sqrt{N} \leq R(1) \leq 2/\sqrt{N}$$



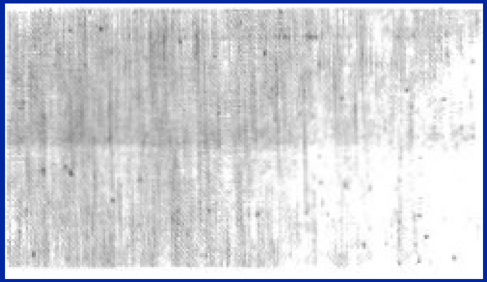
Simply the Autocorrelation function is a comparison of a signal with itself as a function of time shift.

Practical Uster Unevenness

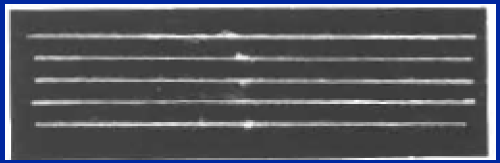
Irregularity: Continuous variation in mass expressed in CV% or U%.



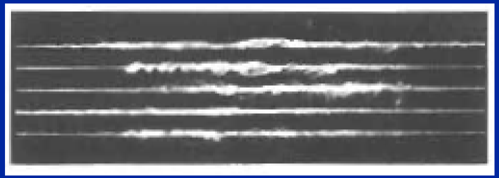
Count Variation: Variation in mass over length measured by weighing 100 m or 120 yards.



Imperfection: Sporadic thin or thick places or neps. Measured as a number per 1000 m of yarn

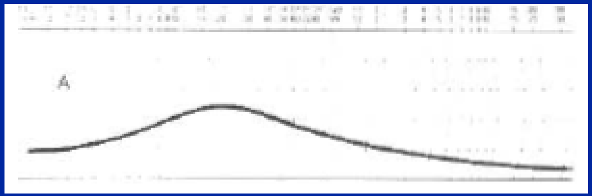


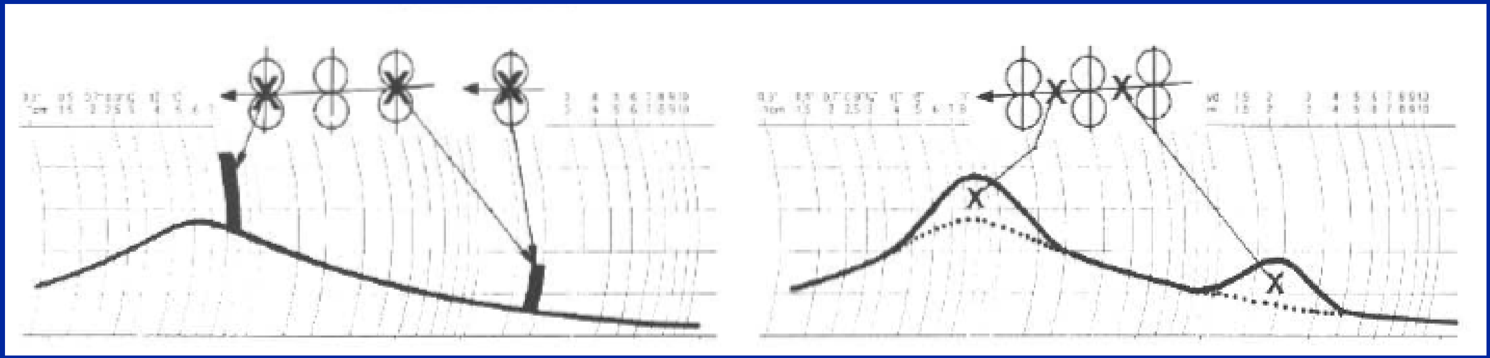
Seldom occurring defects: infrequent large thick places or long thin places, measured on Uster classimat system and expressed in number/ 100000 m.



Practical Uster Unevenness

Ideal Spectrum: Spectrum calculated from fiber distribution. It was found that maximum amplitude is given at about 2.5 to 3 (2.8) * mean fiber length





Mechanical fault caused by machine

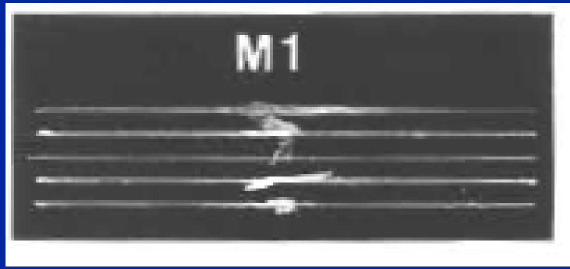
Draft waves due to bad setting Of the draft arrangement

Mass unevenness

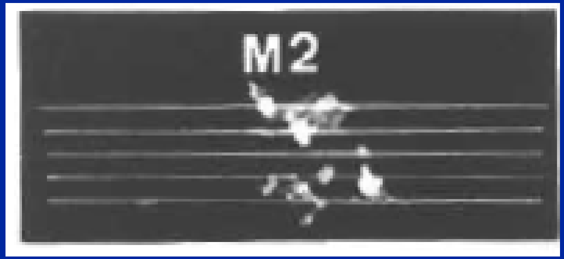
Yarns spun on the short staple cotton spinning system

Foreign Matter in short spinning process

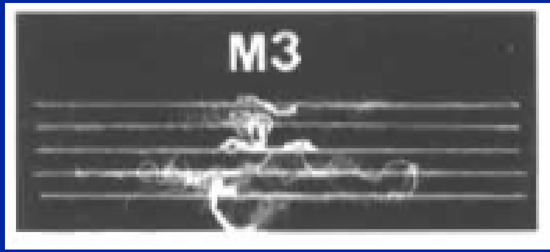
Foreign matter: This type of fault is easy to explain. In most cases it refers to non textile material which is already available in the bales or is colored at some during further processing.



Fiber Entanglement: These entanglements are found primarily in yarn containing mad-made fibers. They consist of fibers which are bonded together and in many cases are combined with collection of finishing agents.

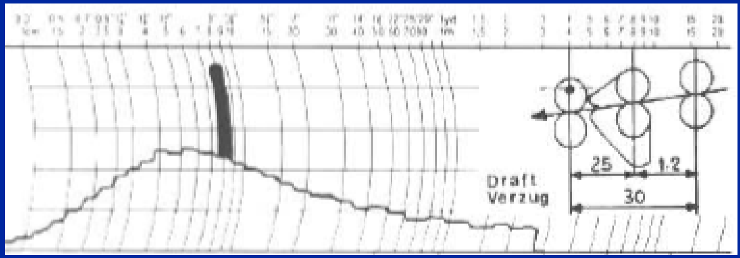


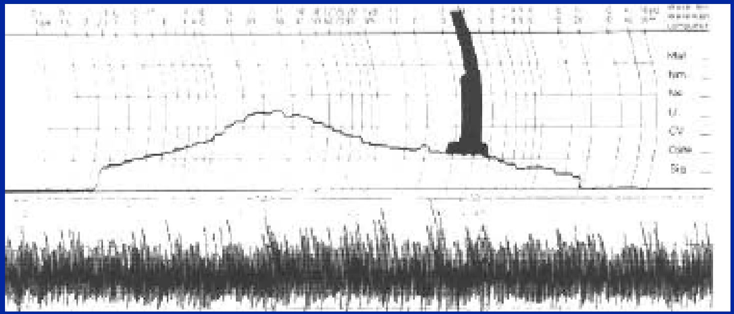
Synthetic un-drawn fibers: These are fibers which are stuck together in the form of single fibers or fiber groups.

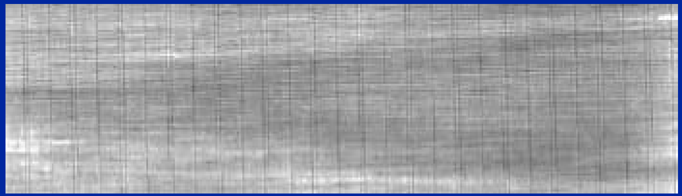


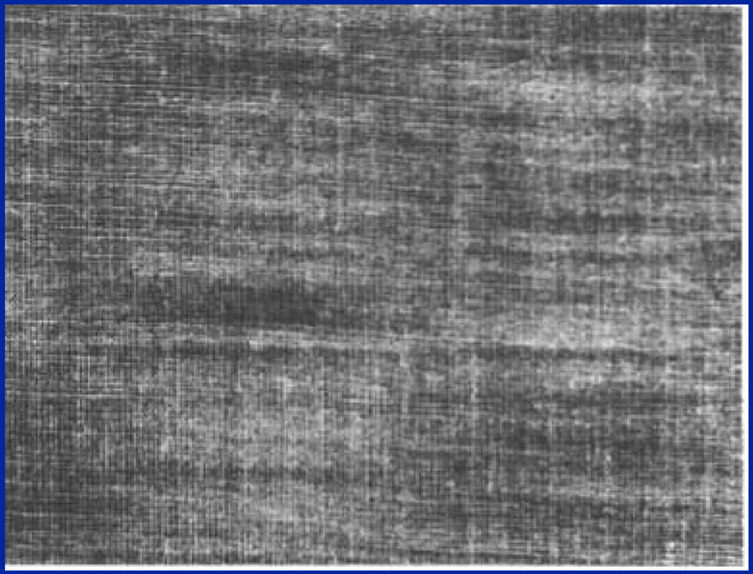
Mass unevenness

Cotton yarn: An eccentric front roller caused a periodic fault identical in length with circumference of roller









CAUSE AND EFFECT DIAGRAM II

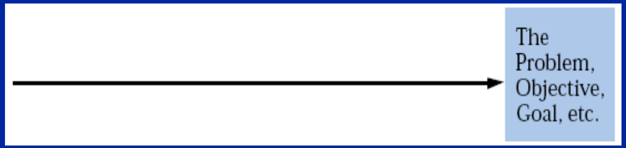
- Graphically illustrates the relationship between a given outcome and all the factors that influence this outcome. Sometimes called an "Ishikawa or "fishbone" diagram, it helps show the relationship of the parts (and subparts) to the whole by:
- Determining the factors that cause a positive or negative outcome (or effect)
- Focusing on a specific issue without resorting to complaints and irrelevant discussion
- Determining the root causes of a given effect
- Identifying areas where there is a lack of data

CAUSE AND EFFECT DIAGRAM II

Constricting the diagram:

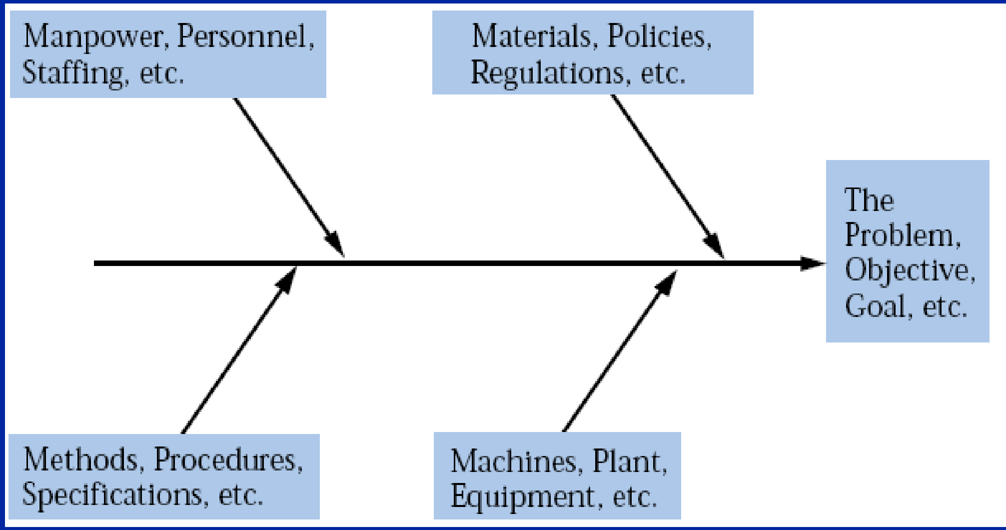
a) Specify the effect to be analyzed. The effect can be positive

(objectives) or negative (problems). Place it in a box on the right side of the diagram.



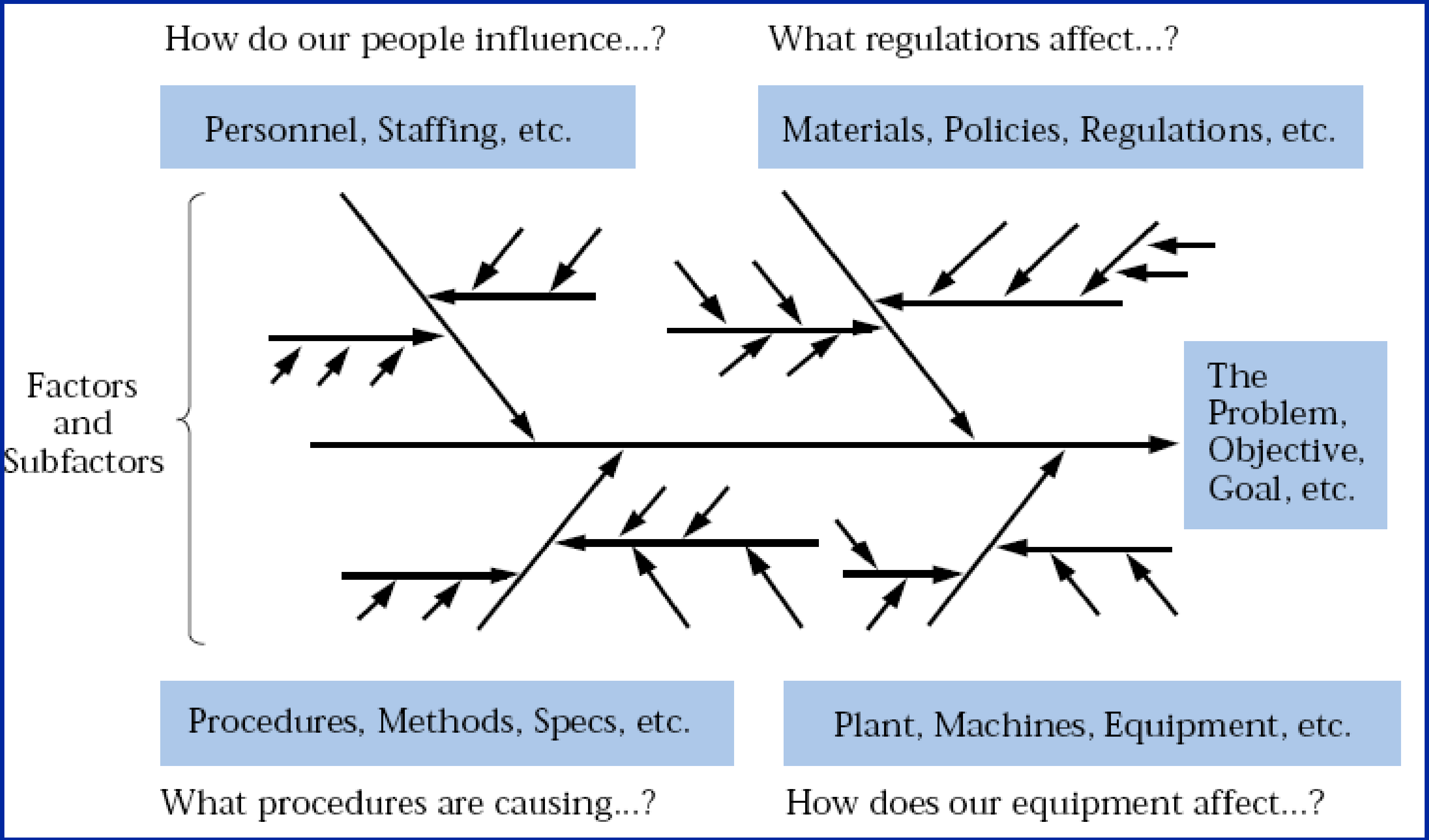
b) List the major categories of the factors that influence the effect being studied.

The "4 Ms" (methods, manpower, materials, machinery) or the "4 Ps" (policies, procedures, people, plant)are commonly used as a starting point



CAUSE AND EFFECT DIAGRAM III

c) Identify factors and sub-factors. **Use an idea-generating technique from Section 2 to identify the factors and sub-factors within each major category. An easy way to begin is to use the major categories as a catalyst. For example, "What policies are causing . . . ?"**

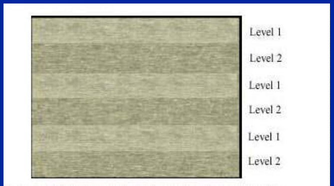


CAUSE AND EFFECT DIAGRAM IV

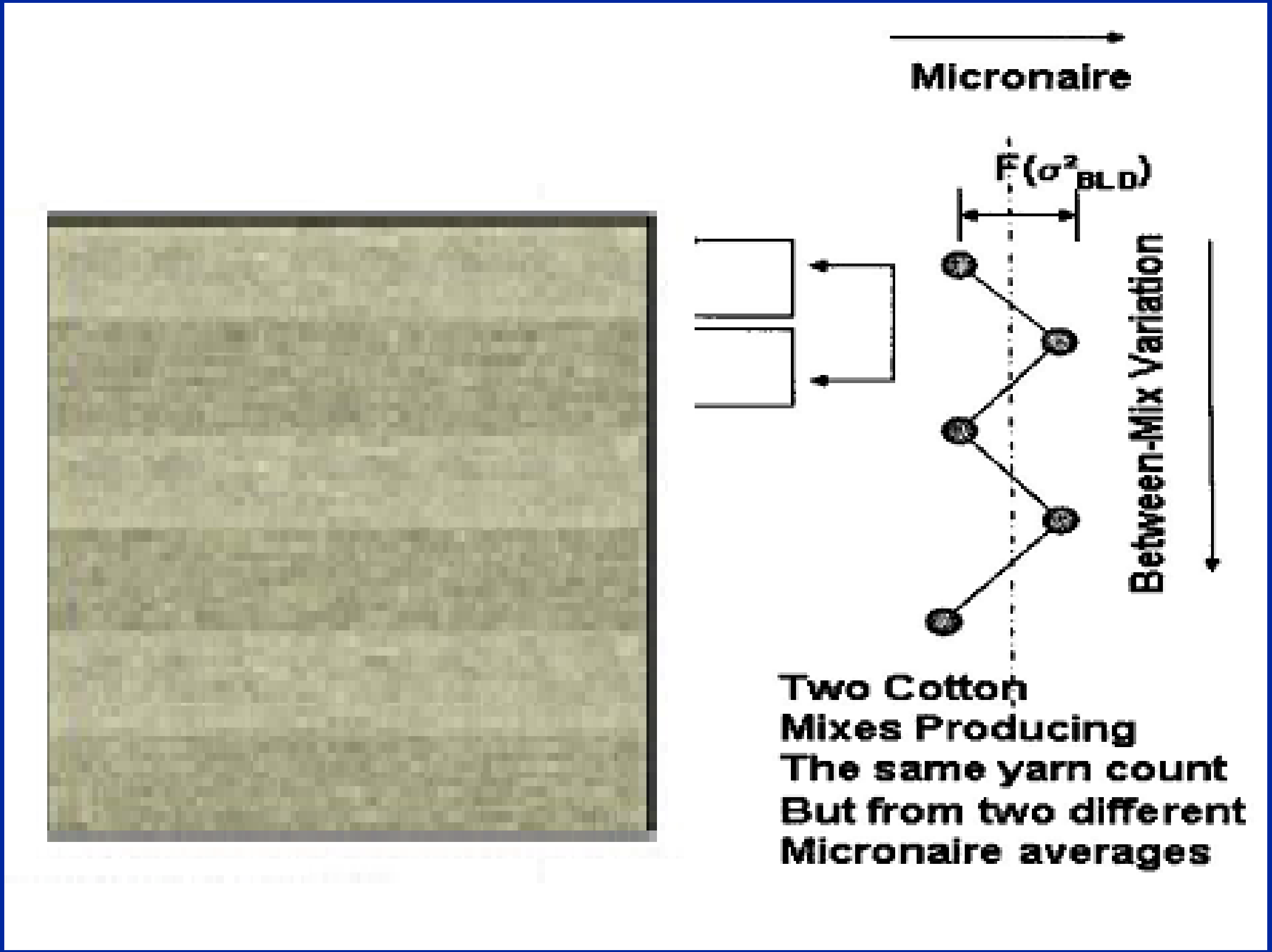
d) Identify significant factors. Look for factors that appear repeatedly and list them. Also, list those factors that have a significant effect, based on the data available.

e) Categorize and prioritize your list of causes. Keep in mind that the location of a cause in your diagram is not an indicator of its importance. A sub-factor may be the root cause to all of your problems. You may also decide to collect more data on a factor that had not been previously identified.

Case Study: Barré Effect



Fabric Barré resulting from Between mix variation



BARRÉ EFFECT I

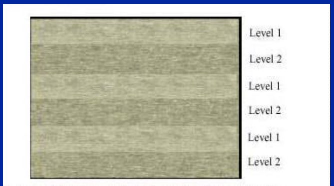
•INTRODUCTION

In textile production, one of the most common and often perplexing quality control problems is barré – repetitive yarn direction streaks. The factors which can cause or contribute to barré are varied and diverse. For this reason, when a barré problem is detected, the skills of a sleuth may be required to track down and eliminate its cause.

•DEFINITION OF BARRÉ

The noun "BARRÉ" is defined by ASTM* as an unintentional, repetitive visual pattern of continuous bars and stripes usually paralleled to the filling of woven fabric or to the courses of circular knit fabric. In a warp knit, barré normally runs in the length direction, following the direction of yarn flow. Barré can be caused by physical, optical, or dye differences in the yarns, geometric differences in the fabric structure, or by any combination of these differences. A barré streak can be one course or end wide or it can be several – a "shadow band". Barré should not be confused with "warp streaks", which in woven fabric are narrow bands running lengthwise and are characterized by apparent differences in color from adjoining ends. Nor should it be confused with "mixed filling", a condition in which a filling yarn differing from the normal filling was accidentally inserted in the fabric.

BARRÉ EFFECT II



VISUAL BARRÉ ANALYSIS:

Naturally, the first step in a barré investigation is to observe and define the problem. Barré can be the result of physical causes, which can usually be detected, or it can be caused by dyeability differences, which may be nearly impossible to isolate in fabric. Barré analysis methods that help to discriminate between physical barré and barré caused by dyeability differences include Flat Table Examination, Light Source Observation, and the Atlas Streak Analyzer.

Flat Table Examination: For a visual barré analysis, the first step is to lay a full width fabric sample out on a table and view both sides from various angles. Generally, if the streaky lines run in the yarn direction, color differences can be seen by looking down at the fabric in a direct visual line. In this way the defect can be positively identified as a barré defect. Viewing the fabric with a light source in the background will show if the barré is physical.

BARRÉ EFFECT III

Light Source Observation

After completing an initial Flat Table Examination, a Light Source Examination may provide further useful information. Full width fabric samples should be examined under two light conditions, fluorescent and ultraviolet (UV) light. Observations that should be made while viewing under lights are:

1. frequency and direction of the barré,

2. whether streaks are dark or light, and

3. total length of pattern repeat.

Ultraviolet light, commonly referred to as "black light", allows the presence of mineral oils to be more easily detected, due to their radiant energy (glow). When observed under UV light, fabrics with streaks that exhibit glow suggest improper preparation. A change in composition or content of oil/wax by the spinner or knitter without appropriate adjustments in scouring can create this problem.

BARRÉ EFFECT IV

Atlas Streak Analyzer: The function of the Atlas Streak Analyzer is to isolate barré caused by physical differences. A fabric swatch is combined with polystyrene sheet film, and the Atlas Streak Analyzer produces a plastic impression of a fabric surface by incorporating specific conditions of pressure and heat. The absence of color on the plastic impression insures that only physical streak effects will be seen. The plastic impression is examined to determine whether the streak alignment matches the streaks observed on the fabric. However, impressions made from spun yarn can be difficult to read due to the inherent yarn variation characteristic of spun yarns. Also, a too rapid cooling of the test specimen can produce a moiré pattern. From a valid plastic impression, the barré source can be identified as:

1. physical-all show on the impression;
2. dyeability variation-none of the color streaks are aligned on the impression;
3. a combination of physical and dyeability differences-some streaks align with those on the impression, some do not.

Fabrics with combination causes present the greatest challenge for analysis.

BARRÉ EFFECT V

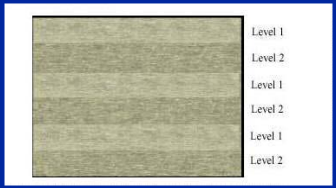
PHYSICAL BARRÉ ANALYSIS:

Physical barré causes are generally considered to be those which can be linked to yarn or machine differences. Methods of physical barré analysis include fabric dissection, microscopy, and the Roselon Knit Extension Tester.

Fabric Dissection: Individual yarns are removed from light and dark streak sections, and twist level, twist direction, and cut length weight determinations are made and recorded. After compilation of yarn information, the numbers can be compared individually to adjacent yarns as well as by groupings of light and dark shades.

Microscopy: Microscopic examination is useful for verifying yarn spinning systems. Yarns from different spinning system can have different light reflectance and dye absorption properties. Ring spinning produces yarn that is smooth. Open end spinning produces yarn with wrapper fibers at irregular intervals. Air jet spinning produces yarn with more wrapper fibers than open end and inner fibers that are more parallel. Microscopy can also reveal a shift in loop formation in knitted fabrics when twist direction (S and Z) differences are present.

BARRÉ EFFECT VI

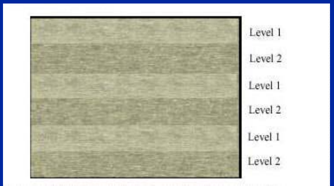


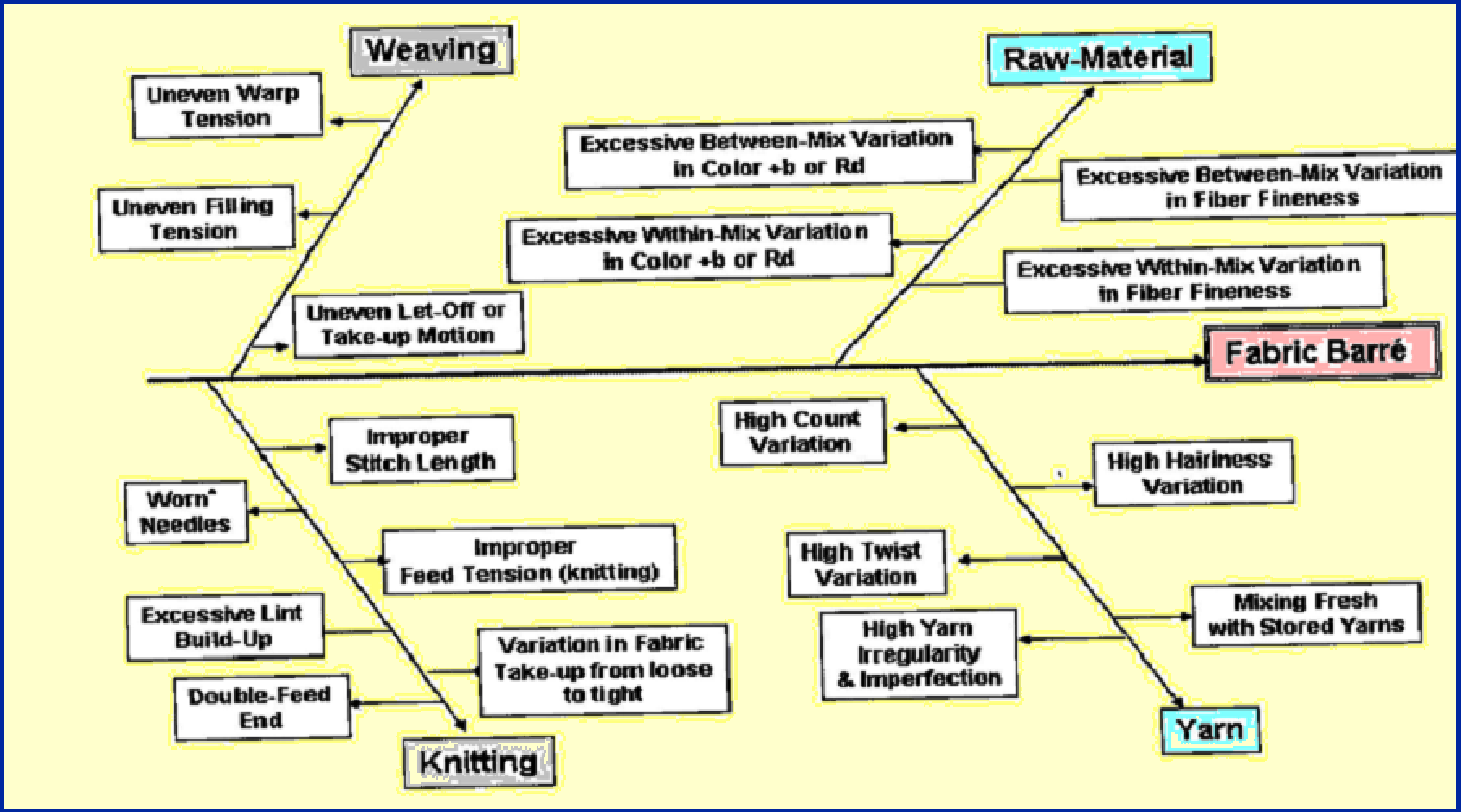
Roselon Knit Extension Tester:

Barré produced by knitting machinery is relatively uncommon, although uneven yarn tension during knitting may be a cause. To test for uneven tension, the Roselon Knit Extension Test can be used. For this test, a fabric sample is cut and raveled to yield yarn samples from light and dark streak areas. The yarn ends are taped and clamped to the tester. As each yarn is stretched

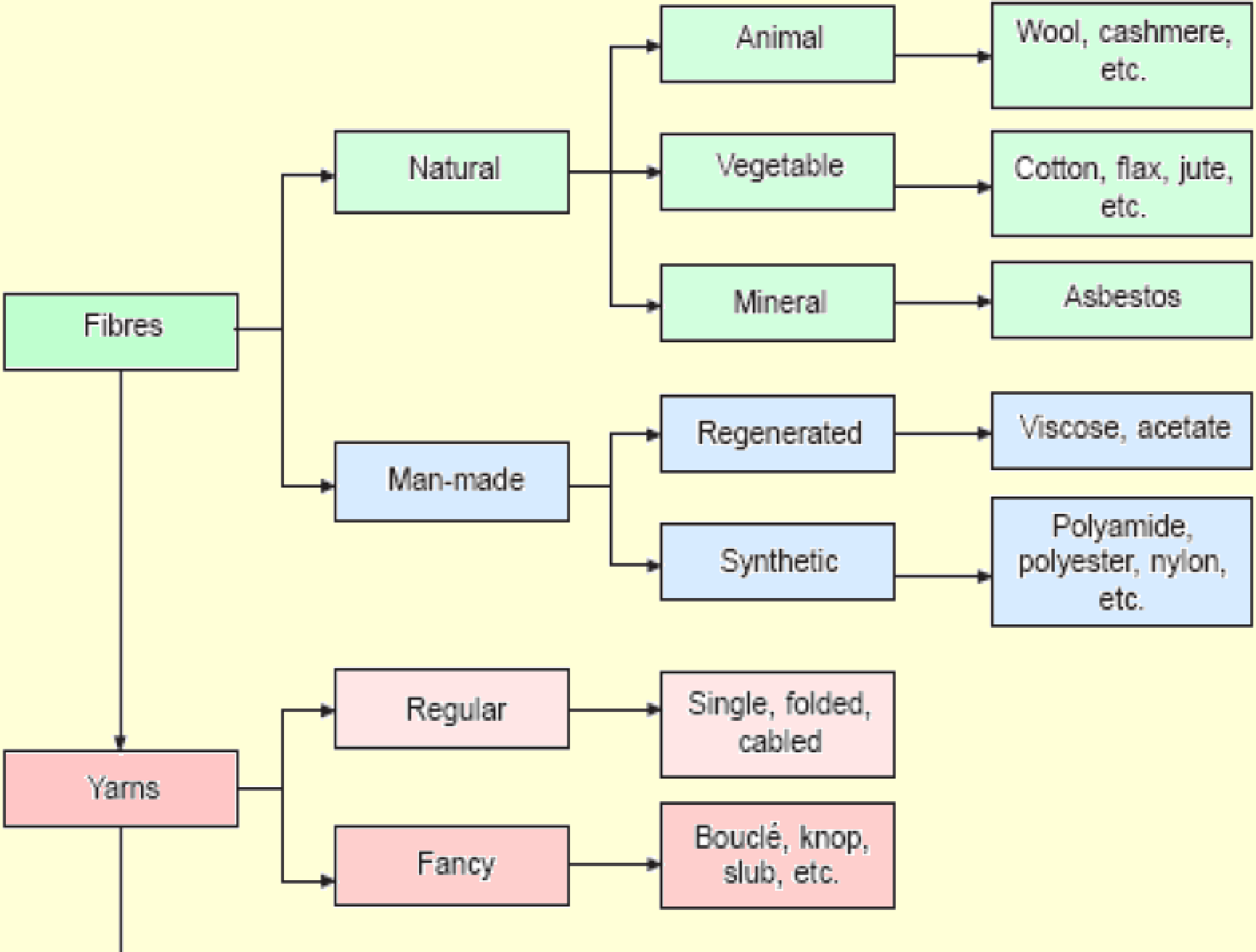
to the maximum extension point, the points are plotted on graph paper. Comparisons are usually made visually rather than mathematically.

POSSIBLE CAUSED OF BARRÉ EFFECT VII

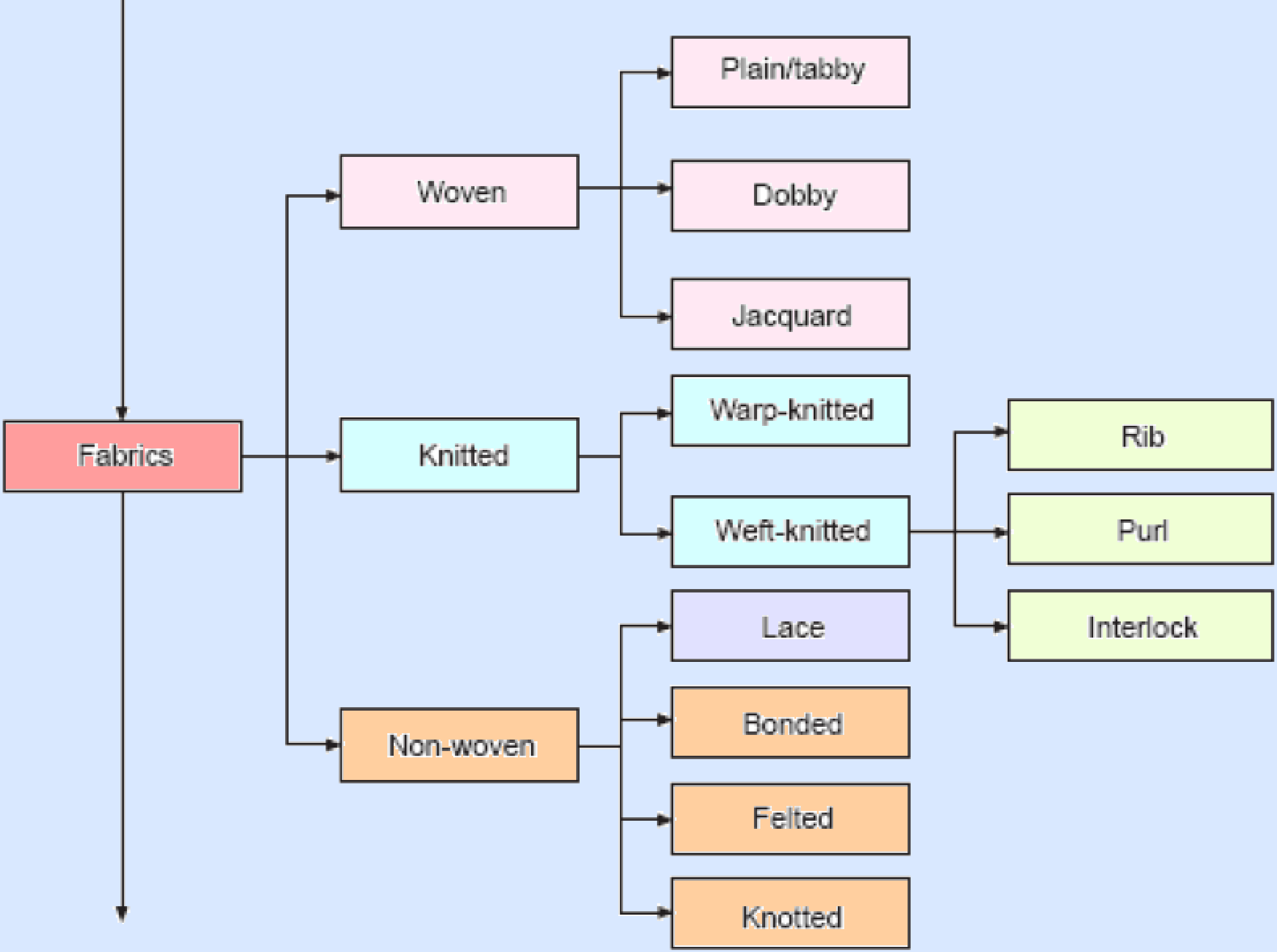


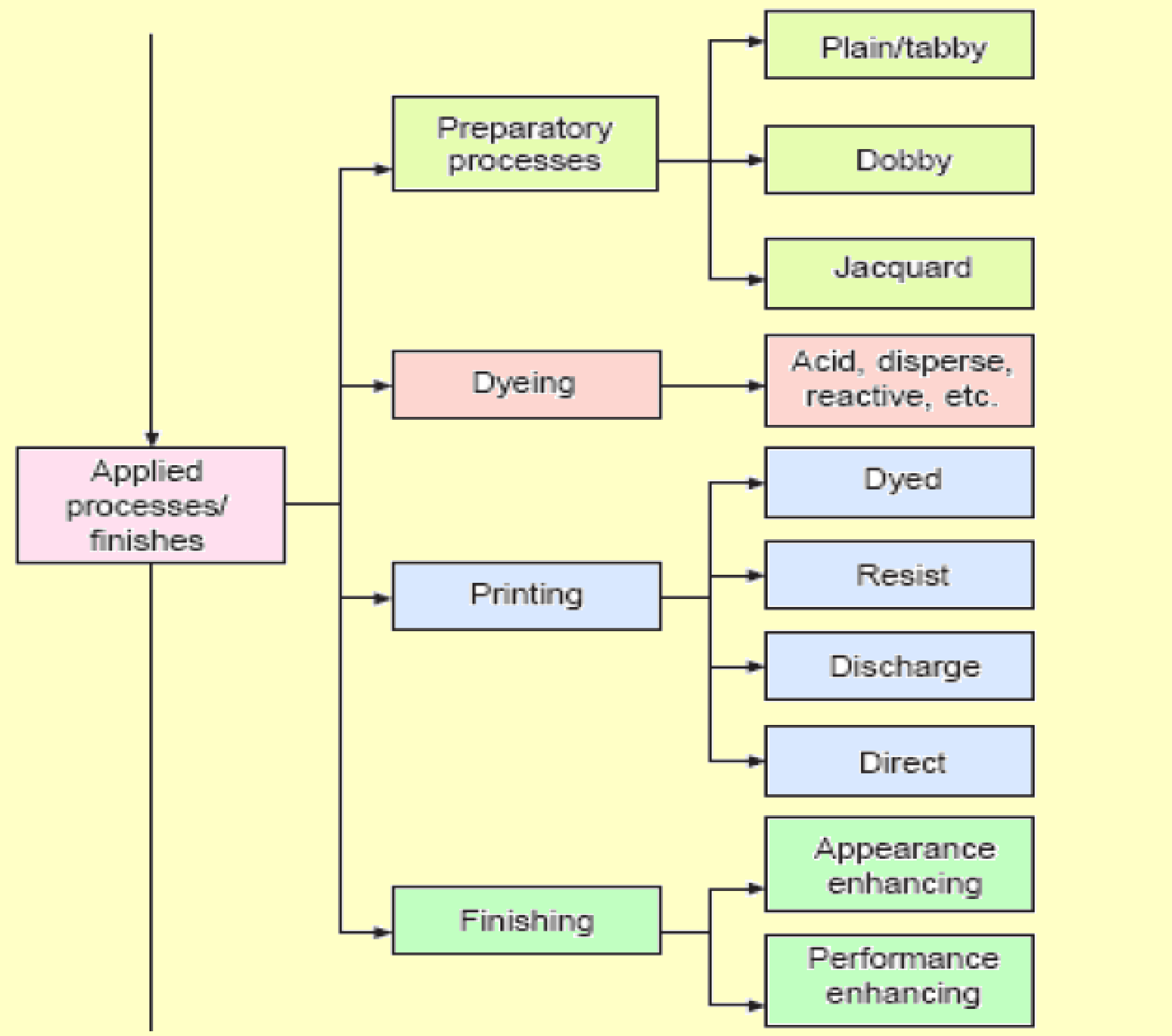


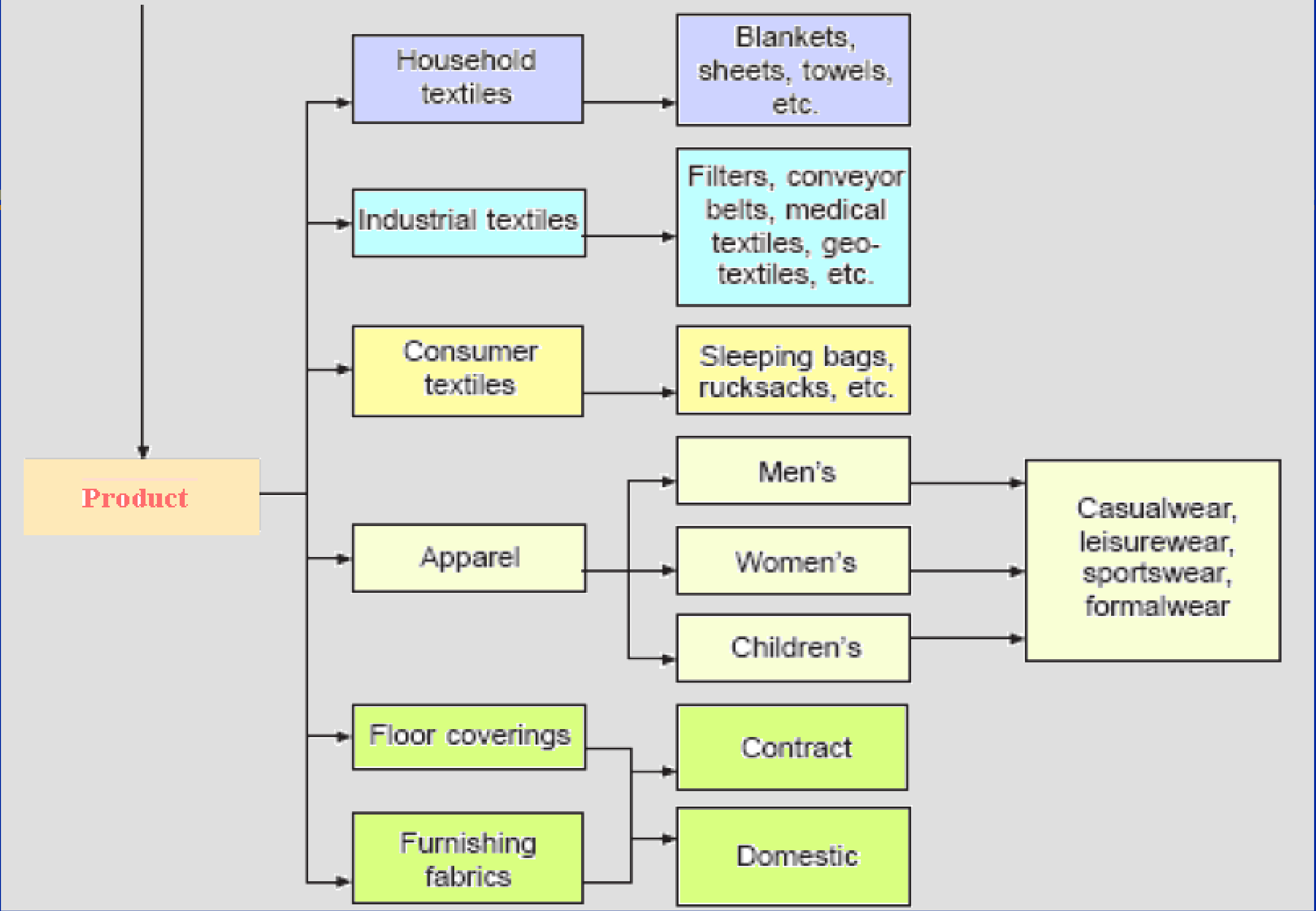
THANK YOU



Fibres
Natural
Man-made
Animal
Vegetable
Mineral
Wool, cashmere, etc.
Cotton, flax, jute, etc.
Asbestos
Regenerated
Synthetic
Viscose, acetate
Polyamide, polyester, nylon, etc.
Yarns
Regular
Fancy
Single, folded, cabled
Bouclé, knop, slub, etc.


Fabrics
Woven
Knitted
Non-woven
Plain/tabby
Dobby
Jacquard
Warp-knitted
Weft-knitted
Lace
Bonded
Felted
Knotted
Rib
Purl
Interlock


Applied processes/ finishes
Preparatory processes
Plain/tabby
Dobby
Jacquard
Dyeing
Acid, disperse, reactive, etc.
Printing
Dyed
Resist
Discharge
Direct
Finishing
Appearance enhancing
Performance enhancing


Product
Household textiles
Blankets, sheets, towels, etc.
Industrial textiles
Filters, conveyor belts, medical textiles, geo-textiles, etc.
Consumer textiles
Sleeping bags, rucksacks, etc.
Apparel
Men's
Women's
Children's
Casualwear, leisurewear, sportswear, formalwear
Floor coverings
Furnishing fabrics
Contract
Domestic