YARN AND YARN MANUFACTURING

An assemblage of fibres that is twisted or laid together so as to form a continuous strand that can be made into a textile fabric. So a yarn is a strand of natural or man-made fibres or filaments that have been twisted or grouped together for use in weaving, knitting, or other methods of constructing textile fabrics. The type of yarn to be manufactured will depend on the fibres selected; the texture, or hand, of the fabric to be made; and qualities such as warmth, resiliency, softness, and durability required in the fabric's end uses.

Types of Fibres:

All the textile fibres are classified according to their staple length into two categories, such as **staple fibre** and **filament.**

Staple fibres:

It has a limited length that varies according to the type, such as cotton, wool, jute etc. There are two types of staple fibre, one is short staple fibre another one is long staple fibre. Cotton is mainly short staple fibre and other maximum natural fibres are long staple except silk. Silk is only natural fibre that is filament.

Filament:

It has continuous length that means the length of filament is equal to the length of yarn. All man-made fibres are filament. Man-made fibres are produced as filament, although they used as staple fibres if necessary. So filaments are used as staple fibre but staple fibres never used as filament.

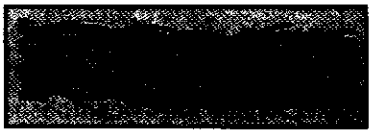
Classification of Yarn:

Classification of yarn according to their structure:

Yarns may be divided into three types according to their structure as follows:

1. **Staple fibre yarns or Spun yarns (Single yarn):**

   Spun yarns are made by mechanical assembly and twisting together (spinning) of staple fibres. Ring spinning, Rotor spinning, Wrap spinning, Air-jet spinning etc. machines are used to produce this spun or single yarns.



Single or Spun yarn

Ring Spun Yarn

Rotor Spun Yarn

Carded cotton (ring) yarn

Combed cotton (ring) yarn

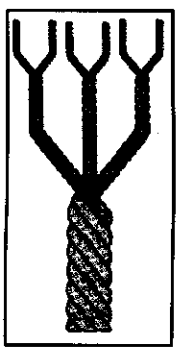
2. Ply yarn:

Single yarns are used in the majority of fabrics for normal textile and clothing applications, but in order to obtain special yarn features, particularly high strength and modulus for technical and industrial applications, ply yarns are often needed. *A folded or ply yarn is produced by twisting two or more single yarns together in one operation, and a* ***cabled yarn*** *is formed by twisting together two or more folded yarns or a combination of folded and single yarns.* The twisting together of several single yarns increases the tenacity of the yarn by improving the binding-in of the fibres on the outer layers of the component single yarns. Ply yarns are also more regular, smoother and more hard wearing. The direction of twisting is designated as S or Z, just as in single yarns. Normally the folding twist is in the opposite direction to that of the single yarns.

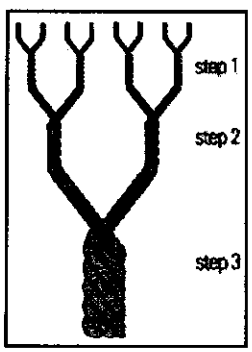
Folded or Ply yarn

Three-Folded or Ply yarn

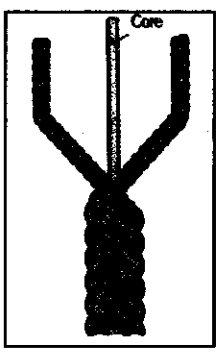
Four-Folded or Ply yarn



Three fold, two-fold Cabled yarn



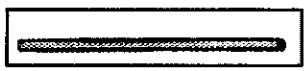
Two-fold, two-fold, two-fold Cabled yarn



Core Spun yarn

3. Filament yarns:

A filament yarn is made from one or more continuous strands called filaments where each component filament runs the whole length of the yarn. Those yarns composed of one filament are called **monofilament yarns**, and those containing more filaments are known as **multifilament yarns**. *For apparel applications, a multifilament yarn may contain as few as two or three filaments or as many as 50 filaments.* In carpeting, for example, a filament yarn could consist of hundreds of filaments. Most manufactured fibres have been produced in the form of a filament yarn. **Silk is the only major natural filament yarn.**



Mono-filament yarn

Flat multi-filament yarn

Twisted multi-filament yarn

False-twist Textured yarn

Stuffer-box Textured yarn

Knit-deknit Textured yarn

According to the shape of the filaments in the yarn, filament yarns are classified into two types, **flat and bulk**. The filaments in a flat yarn lie straight and neat, and are parallel to the yarn axis. Thus, flat filament yarns are usually closely packed and have a smooth surface. The bulked yarns, in which the filaments are either crimped or entangled with each other, have a greater volume than the flat yarns of the same linear density.

Texturing is the main method used to produce the bulked filament yarns. A textured yarn is made by introducing durable crimps, coils, and loops along the length of the filaments. As textured yarns have an increased volume, the air and vapour permeability of fabrics made from them is greater than that from flat yarns. However, for applications where low air permeability is required, such as the fabrics for air bags, flat yarns may be a better choice. Textured yarns are used for Stockings and tights, swimwear, sportswear, outerwear, underwear, carpets, sewing and overedge stitching threads for extensible fabrics.

Classification of Yarns according to their use:

Yarns may be divided into two classifications according to their use:

Weaving yarns and knitting yarns.

Weaving Yarns:

Yarns for woven cloth are prepared for the intended end use. Yarns to be used in the warp, the lengthwise direction of a cloth, are generally stronger, have a tighter twist, and are smoother and more even than are yarns used for filling, the crosswise direction of a cloth. Novelty yarns may be used in the warp, but they are generally found in the filling. Highly twisted crepe yarns are usually found used as filling yarns.

Knitting Yarns:

These may be divided into yarns for hand knitting and yarns for machine knitting. Knitting yarns are more slackly twisted than yarns for weaving. Hand knitting yarns are generally ply, whereas those for machine knitting can be either single or ply. The following are some of the yarns used for hand knitting:

1. Knitted worsted: The four-ply all-around yarn used for accessories, for the house, and for apparel. This is the most common weight of hand-knitting yarn, comprising 90 percent of the handmade yarn business.
2. Fingering (baby or sock) yarn: The fine yarn that was originally wool, but is found most commonly in acrylic for comfort and ease of care.
3. Sport yarn: The three-ply yarn used for socks, sweaters, and hats.
4. Shetland yarn: The two-ply yarn used for sweaters.
5. Fashion or novelty yarn: Any novelty structure.

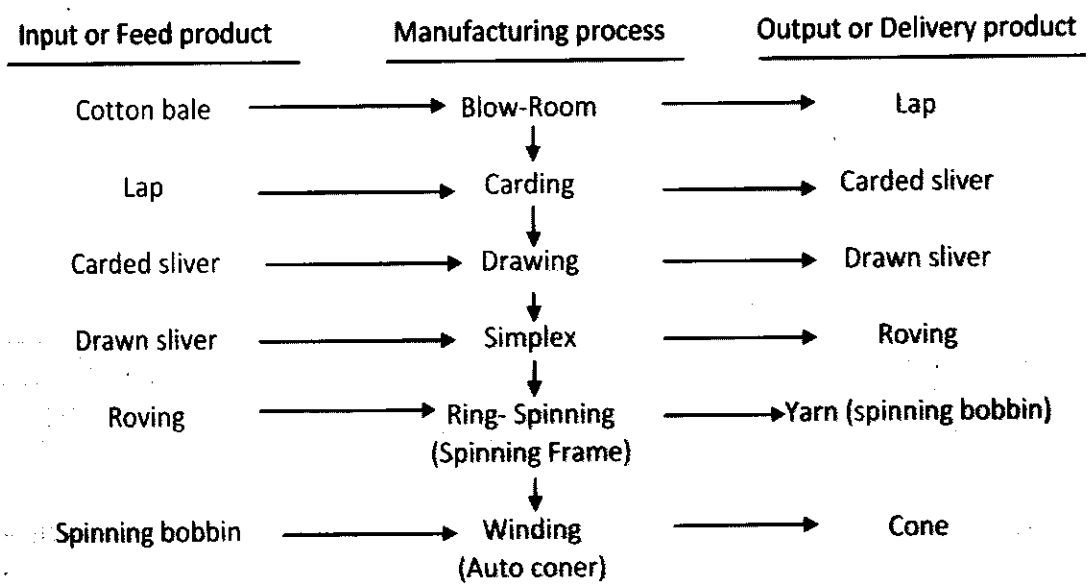
All the yarns listed may be found in any fibre. Of the major fibres, rayon is the least likely to be used in the handmade yarn business.

Types of cotton yarn:

There are two types of cotton yarn according to their manufacturing process as follows:

I. Carded yarn
II. Combed yarn

Flow chart of carded yarn manufacturing with input or feed and output or delivery product:



Blowroom Section:

Basic operation in the Blow-room:

- Opening the cotton bale
- Cleaning the cotton fibre
- Dust removal
- Mixing and blending of fibres
- Even or uniform feed of material to the next process i.e. card.

Objects of Blow-room:

The basic purpose of blow-room line is to supply following qualities of fibre tufts to the carding process.

- Small fibre tufts
- Homogeneously mixed or blended tufts
- Clean fibre tufts
- Convert fibre tufts into a fibrous sheet, is called lap.

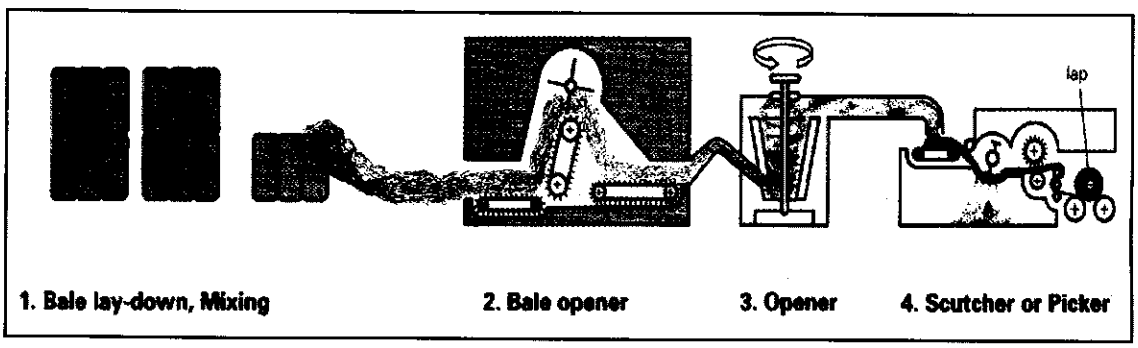
Blending: The method of mixing different fibres within a specific ratio is known as blending.

Mixing: The method of combining identical fibres in various grade of different ratio is known as mixing.

Conventional Blowroom line:

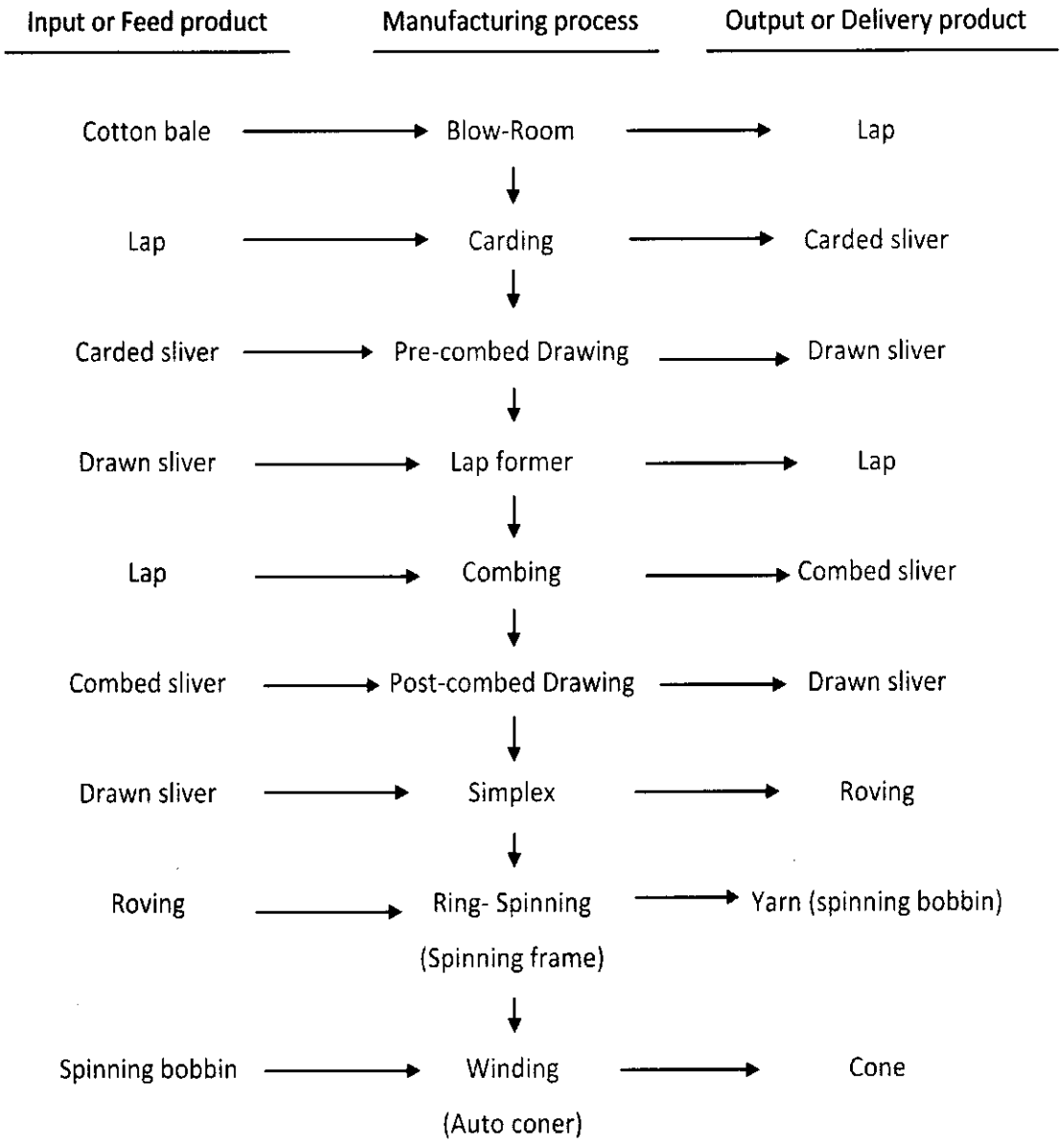
There are different types of conventional blow-room line. It differs manufacturer to manufacturer. For example a typical blow-room line as follows:

1. Hopper bale opener
2. Ultra cleaner or step cleaner
3. Vertical or twine opener or cleaner
4. Hopper feeder –1
5. Porcupine opener
6. Hopper feeder –2
7. Scutcher.

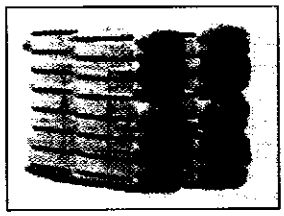
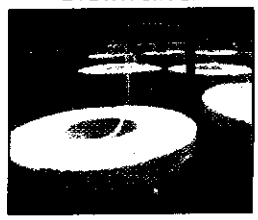
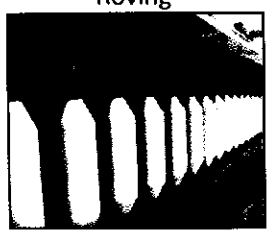
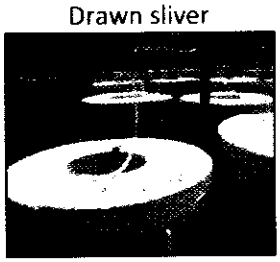
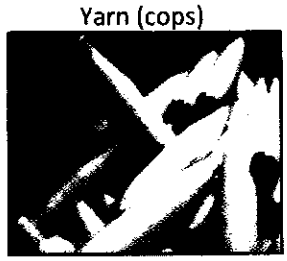
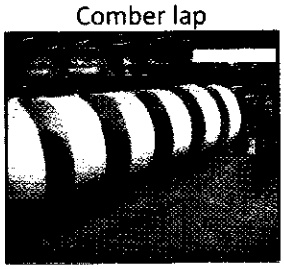
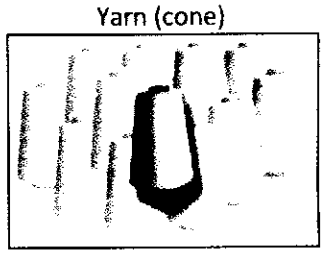


Typical conventional Blow-room line

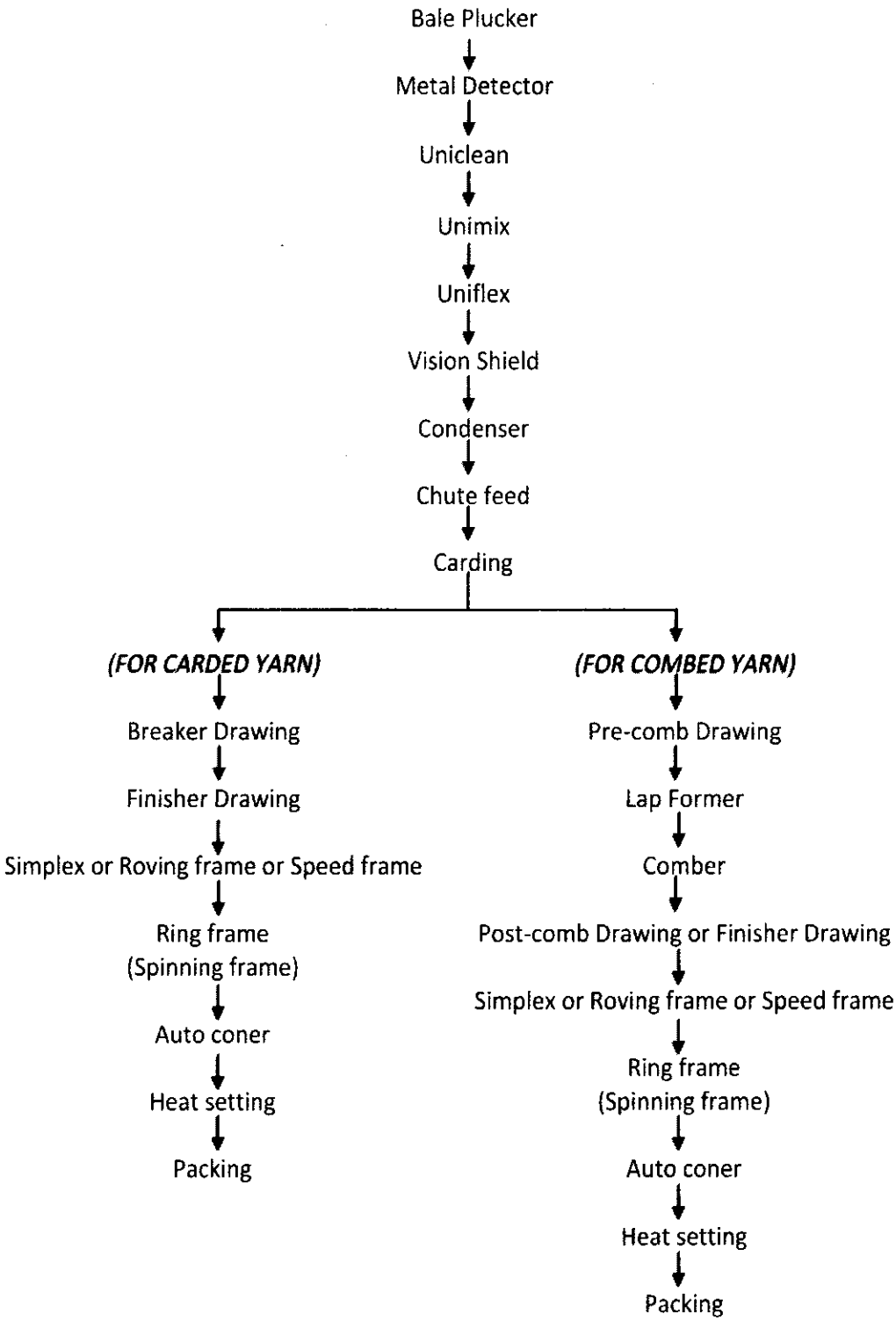
Flow chart of combed yarn manufacturing with input or feed and output or delivery product:



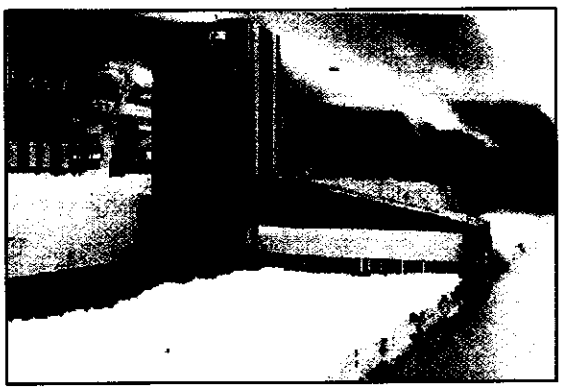
Process and Product of the cotton Ring Spinning:

Process	Product	Process	Product
1. Mixing and Blending	Cotton bale 	6. Combing	Combed sliver 
2. Blow-Room	Cleaned cotton 	7. Finisher Drawing	Drawn sliver 
3. Carding	Carded sliver 	8. Simplex	Roving 
4. Breaker Drawing	Drawn sliver 	9. Ring Spinning	Yarn (cops) 
5. Lap forming	Comber lap 	10. Winding	Yarn (cone) 

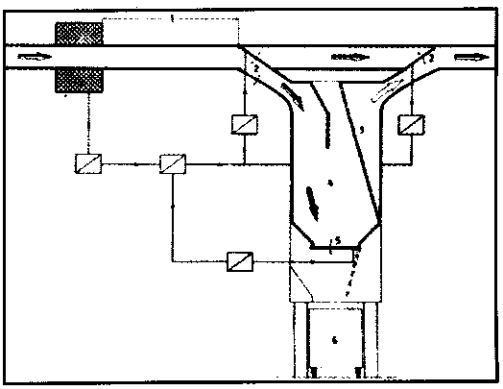
Process Layout of the yarn manufacturing system with a modern Blow-room line:



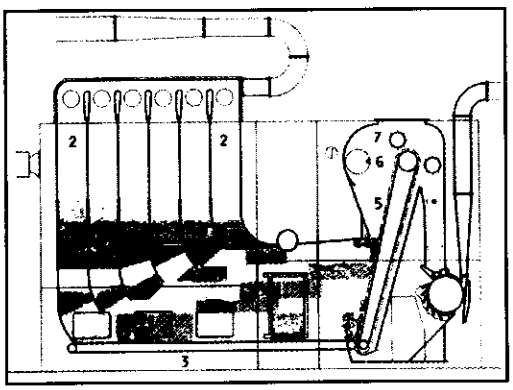
A modern blow-room line as follows: The following blow-room line provide by the Trützschler.



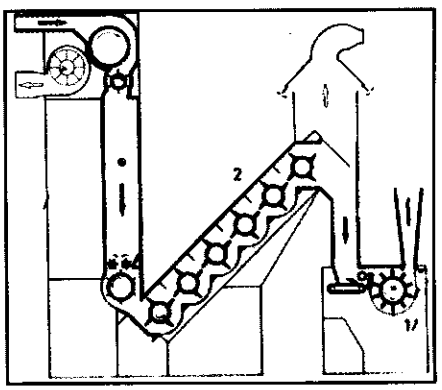
Bale plucker or bale opener



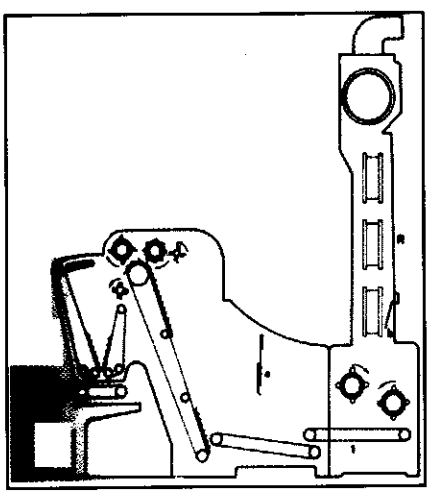
Electronic metal extractor (Trützschler)



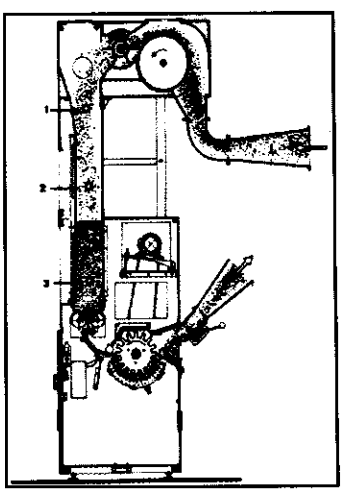
Rieter Unimix



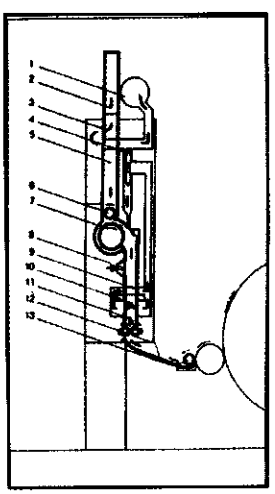
Trützschler *RN* cleaner



Regulated feed of material in the blowroom



Optical regulation



Trützschler chute feed

Modern Blow-room section

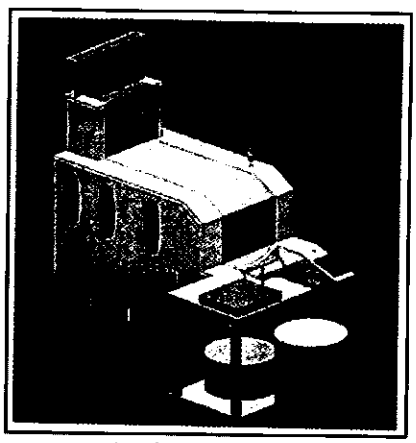
Carding Section:

Carding is a process in which fibres are opened (almost to single fibre staple), parallelised and removes dust, impurities, neps, short fibres to produce a continuous strand of fibres called sliver of uniform weight per unit length.

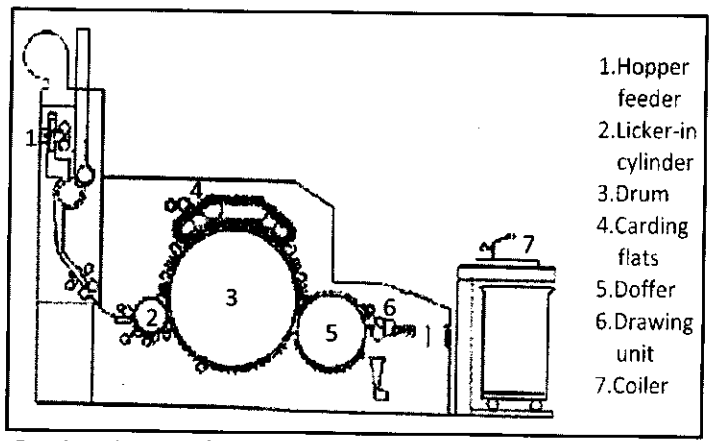
Objects of Carding:

Carding is one of the most important operations in the spinning process as it directly determines the final features of the yarn, above all as far as the content of neps and husks are concerned. There are many objectives of the carding process and these can be summarized as:

- Individualization of the cotton fibre at a single fibre staple state i.e. opening the tufts into individual fibres;
- Elimination of the remaining impurities i.e. eliminating all the impurities contained in the fibre that were not eliminated in the previous cleaning operations;
- Disentangling of neps i.e. removal of neps;
- Selecting the fibres on the basis of length, removing the shortest ones;
- Fibre blending and orientation;
- Parallelising and stretching of the fibre;
- Finally produce a continuous strand of fibres called sliver of uniform weight per unit length i.e. transformation of the lap into a sliver, therefore into a regular mass of untwisted fibre.



Carding machine



Sectional view of the carding machine with hopper feeder

The carding operation is carried out by the card, a machine that in practice is a system of rotating organs, mobile and fixed flats, covered with steel spikes that go by the name of wiring.

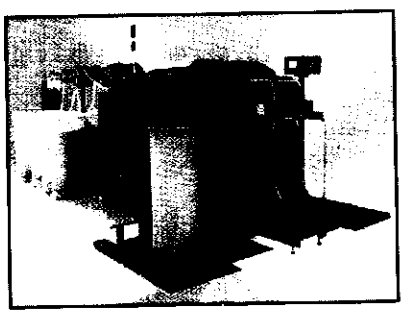
Doubling and Drawing:

In preparing the fibre tufts for spinning, doubling and drawing represent two essential operations and their combined effect permits a sliver with a more regular section to be obtained(through doubling) equipped with parallel fibres (through drawing) as well as the count requested by the spinning plan.

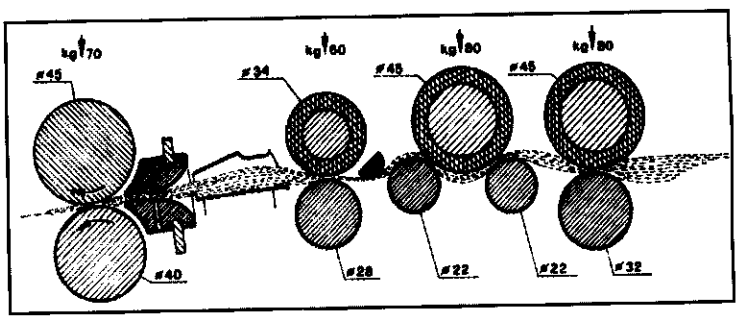
The drawing operation done with the machine called the drawframe, permits a homogeneous blend both with fibres of the same nature as well as fibres with a different nature; the doubling steps are usually between four and eight.

On a par with fibre characteristics such as length and fineness, a sliver with parallel fibres permits a yarn with better regularity and resistance. The drawing depends on some factors such as the number of doublings carried out and the value of the count of the entry sliver and delivery sliver. With drawing, curls, crimps and hooks are also eliminated, meaning the fibres folded in on themselves, present in the carded sliver.

Drawing is a process in which the sliver is elongated by passing it through a series of pair of rollers, each pair moving faster than the previous. This permits combination of several slivers and drawing and elongating them to straighten and create greater uniformity to form a regular sliver of smaller diameter. This action pulls the staple lengthwise over each other, thereby producing longer and thinner slivers. Finally the sliver is taken to the sliver can.



Draw frame



3-cylinder drafting unit on top of 4, with pressure bar

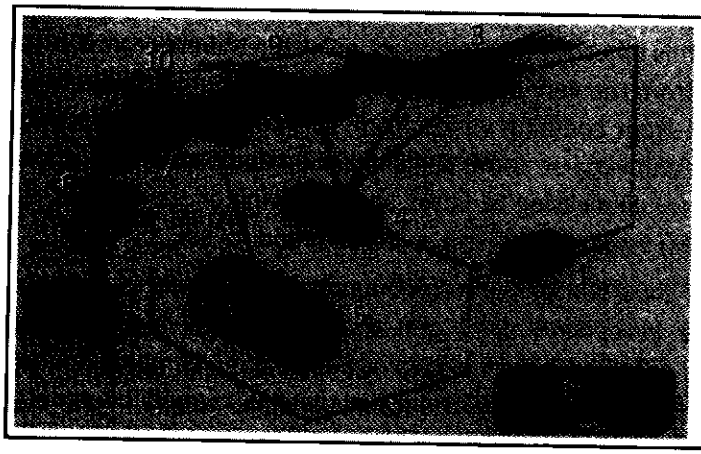
The main objects of the Draw-Frame are below:

- Crimped, curled and hooked fibres are straightened;
- Parallelisation of fibres;
- Reduction of sliver weight per unit length;
- Reduce irregularities of fibres by doubling and drafting;
- Remove remaining dust from sliver;
- Blending of fibre to provide compensation of raw material variation.

There are two passages of drawing are uses

- Breaker drawing and
- Finisher drawing

The main difference between them, like on the card, there are also autolevelers on the finisher drawframes, whose job it is to correct the draft in function of variations in the fibrous mass, to maintain the section of sliver as even as possible and therefore reduce the frequency of breaking threads in spinning and in successive operations.



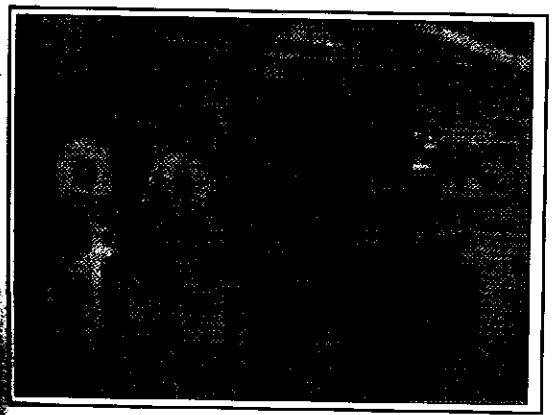
1. Autoleveller module
2. On-board computer
3. Measurement unit
4. Servomotor
5. Main motor
6. Monitoring sensor
7. Web condenser
8. Delivery rollers
9. Pre drawing
10. Main draft

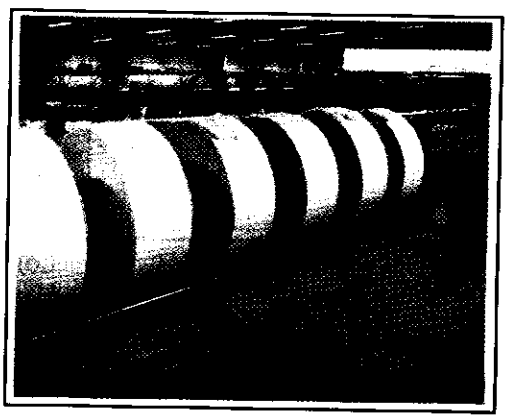
Draw frame Auto leveler

Combing section:

The Lap former:

The lap former has, furthermore, the task of forming the interfacing or lap, which is employed to feed the combing machine. The lap is obtained by doubling a certain number of slivers (from 16 to 32) previously subject to a drawing passage. The slivers are fed side by side, passing through rollers and stop motion. The slivers enter the drafting section and then calendar section to produce a compact lap. Finally the lap is wound on to bobbin. In the lap former, the material undergoes a light draft of around 1.5 to 2 times one a drawing aggregate of the type 2 on top of 3 cylinders.





Lap former

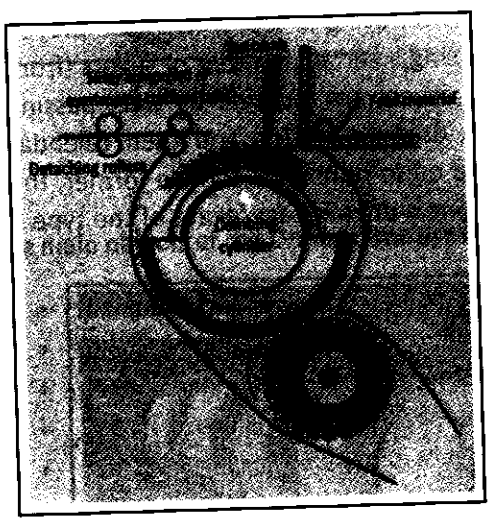
Combing:

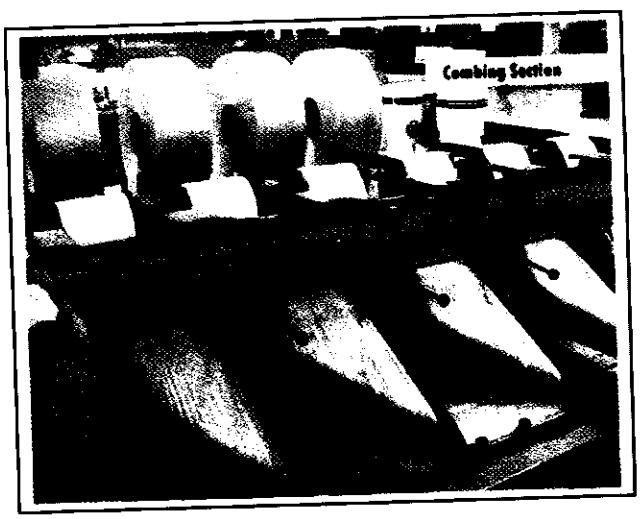
The combing process is carried out in order to improve the quality of the sliver coming out of the card. The process eliminates a controlled proportion of the shortest fibres, it achieves better parallelization of fibres, it straightens curls, and it removes neps and residue impurities. It is clear from these functions that the combing process is essentially aimed at obtaining excellent quality yarns and to fulfil this objective raw materials with above average physical and mechanical features must be used from the very beginning of the spinning process. Depending on what is being produced, waste from combing varies from 12% to 25%, and this can be employed to obtain yarns with a medium-coarse count using the open-end process. So combing may be defined as straightening and parallelising of fibres and removing of short fibres, neps and impurities by using comb (combs) associated by knives, brushes and rollers.

For the production of fine and very good quality yarns combing process is essential. Fine tooth combs continue straightening the fibres until they are arranged with a high degree of parallelization that the short fibres, called noils are combed out up to 25%. Combing operation is not done when man-made fibres are processing. Finally a sliver is formed by necessary drafting.

The main objects of the combing are below:

- To remove short fibres below a pre–selected length so that the spinner enable to produce finer yarn / better yarn that cannot be possible in carding state.
- To remove neps and foreign matter from the cotton.
- More straighten and parallisation of the fibres.





Combing operation

Contribution of combing to yarn quality:

- Improve the uniformity and strength
- Improve the spinning value of fibre

- Reduce the neps in the yarn.

$1\frac{1}{8}$" staple length = 30Ne carded yarn

= 60Ne combed yarn

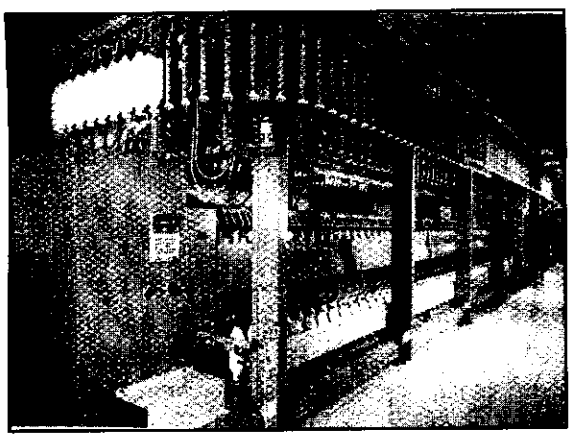
- Improve yarn smoothness and lusture
- Produce much clearer yarn
- Improve/Increase efficiency of the next process
- Reduce the hairiness of yarn
- Improve better twist distribution in the yarn

Simplex or Roving frame:

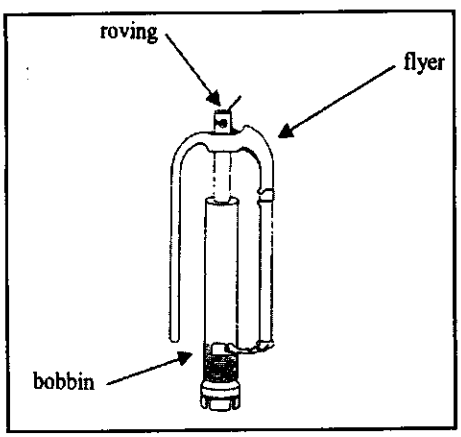
The task of this machine is to transform the sliver coming from the drawframe into roving. It is present in the carded ring spinning cycle and in the combed ring spinning cycle, in the first case it is found following the post-carding drawframe (one or two drawing steps), while in the second case after the post-combing drawframe. Further drafting of the slivers and twisting take place until the cotton stock is about to a very small diameter which is called roving. Roving is the final product of the preparatory process. For the rotor spinning system this process can be eliminated. Roving has no tensile strength; it will break apart easily with any slight pull.

Transform the sliver into roving occurs in a continuous manner through three stages:

- Drawing
- Twisting
- Winding



Roving frame



Flyer and bobbin

Drawing is generally carried out by a draft system with 3-cylinder weighing arm with double apron capable of working with entering sliver counts of 0.12 N_e to 0.24 N_e and counts of the delivered roving of 0.27 N_e to 3 N_e.

The twist is given by the rotation of the flyer located on the spindles, in fact the exit roving coming from the draft cylinders enters in the higher hole of the flyer, passing through the hollow arm and then winding on the bobbin. The twist value is given by the following equation:

$$\text{No. twists} = \frac{\text{Revolutions of the spindle (flyer)}}{\text{Exit length 1st cylinder}}$$

The number of revolutions of the spindle can reach up to a maximum value of 1500 rpm. The twist rate given by the roving has a value of between 10 to 100 T/m (0.25 T/inch). It should be noted that the twist value to give the roving, this being an intermediate product, has a fundamental practical importance for the next processing stage.

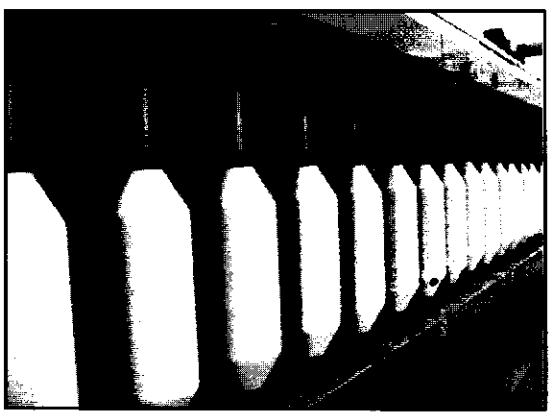
The thread is wound by the action of the bobbin rotating at a higher speed than the flyer (spindle), in order that on every turn the bobbin makes in addition to the spindle, a coil of roving is wound on the bobbin. The length of coil is shorter for the first lay ers and longer for the last.

Objects or functions of speed frame:

- Attenuation of drawframe, sliver to form roving of required hank by drafting.
- Insert small amount of twist to give required strength of roving.
- Winding the twist roving on to the bobbin
- Build the roving in bobbin such a form, which will facilitate handling with drawing and transfer to the next process.

Operations involved:

- Creeling
- Drafting
- Twisting
- Winding
- Building
- Doffing



Roving

Cotton spinning system:

In the cotton spinning system one differentiates between two kinds of yarns:

a) Carded yarn:

After the fibre material has been opened (loosened), cleaned and, if necessary also blended in the first stage, it is resolved into the state of individual fibres on a card and deposited in the form of a sliver (carded sliver). In the next stage several carded slivers are presented to a

drafting unit on a draw frame. Drafting leads to a reduction of the fibre mass per sliver. Subsequently the individual slivers, now with a lower mass, are collected together to form a draw frame sliver. Compared to the carded sliver the drawn sliver displays

- a better fibre alignment towards the longitudinal axis of the sliver and
- a higher degree of parallelization between the fibres.

A yarn finally spun out of this sliver is called a carded yarn.

b) Combed yarn:

In the cotton spinning system a combing of fibres out of draw frame slivers is basically an additional processing stage. Combing leads to the following results:

- A pre-determined portion of short fibres is combed out (comber waste). This is significant in the case of cotton, which as a natural fibre contains fibres in varying lengths. Comber waste can amount to as much as 20% to 30% of the original weight of the fibre lot being processed on the comber. The portion of longer fibres is increased in the combed material. With regard to the spinning limits the following rule is valid:

  The longer the fibres are, the finer one can spin
  The shorter the fibres are, the lower is the spinning limit.

  Thus one can spin finer yarns from the fibre lot (sliver) after combing

- Combing leads to a higher degree of cleanliness in the fibre material.

Compared to carded yarns a combed yarn has a softer handle. This property is also transferred to fabrics made out of it.

Spinning machine

This is the final stage of yarn manufacturing. The goal of this manufacturing process to get yarn is achieved by this machine. There are different types of spinning machine. Ring frame is a conventional spinning machine. This machine has very wide scope, because it can produce coarse to very fine yarn. Till now this ring spinning machine is widely used whole over the world.

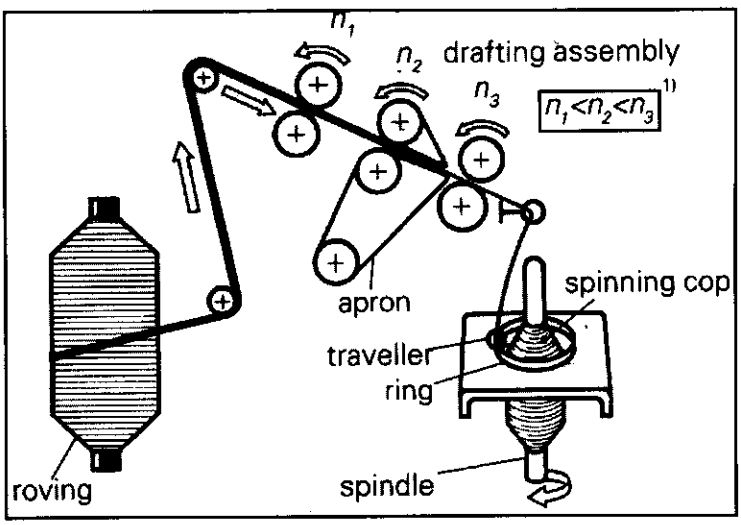
There are also some modern spinning systems too. Rotor spinning system is one of them. This system is also very famous, but it has some limitation. It is mainly used for coarse yarn.

In the following section the currently most important spinning techniques are described in some detail.

Ring Spinning machine:

This is comparatively the oldest spinning technique and is therefore also referred to as the classical or conventional process.

Fibre material supply to the ring spinning machine is in the form of a roving. Its fibre mass is reduced in a drafting unit. The twist inserted moves backwards and reaches the fibres leaving the drafting unit. The fibres lay around one another in a heliocoidal manner. The normal forces generated here enlarge the adhesive forces between the fibres and prevent the fibres from "flying off" under tensile strain.

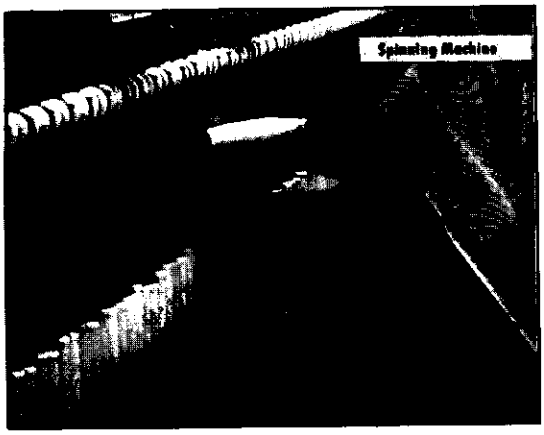


Principle of Ring Spinning

A driven spindle, on which the yarn package (tapered bobbin tube with yarn) firmly sits, is responsible for twist. Around the spindle is a stationary ring. Yarn from the drafting unit is drawn under a traveler (a small metal piece), freely moving on the ring, and then led to the yarn package. This traveler, lagging because of the yarn drag on it, is responsible for winding-on the yarn. A controlled up and down movement of the ring determines the shape of the yarn package, called a cop or spinning bobbin.

With the ring spinning technique all known yarn counts can be spun and thus the entire count range is covered (0.3 N_e to 148 N_e or 4 tex to 2000 tex)

Compared to other spinning methods the ring spinning technique, however, has the lowest performance with a maximum of about 20 m/min. One significant reason for this is that the entire yarn package must insert the full amount of twist into the yarn; it therefore cannot become too large. Twist insertion and yarn wind-on take place in one continuous process. The method used for this leads to large yarn tensions and tension fluctuations with increasing package diameters and prevents the productions of large *packages. Thus the running length of yarn on a cop is relatively short.*

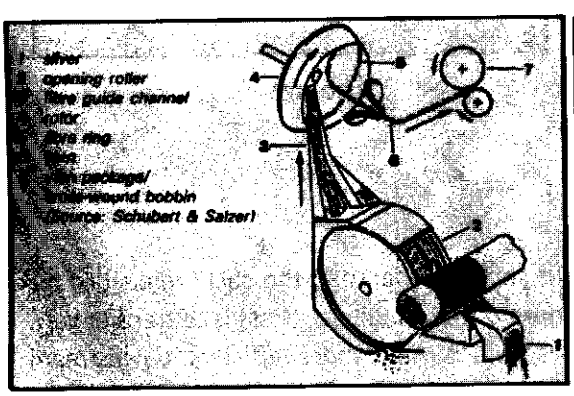


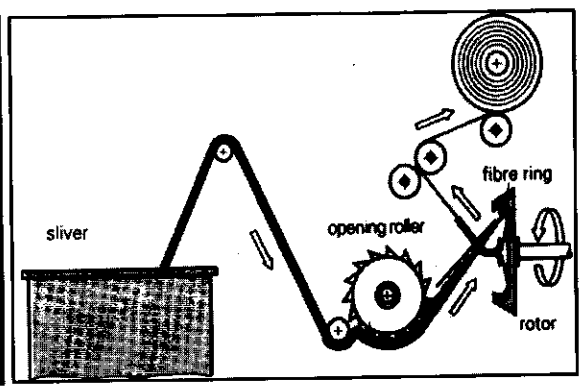
Spinning bobbin

OE Rotor Spinning machine:

One common aim of unconventional spinning techniques is to exceed the performance of ring spinning. This is mainly achieved by separating the process of yarn formation from that of yarn winding-on. One result is that the yarn can be wound on at higher speeds.

As a rule the spinning machine is supplied with fibres from the drawn sliver. Fibres processed on short staple spinning can also be present in combed slivers. The production of a roving (needed for ring spinning) is superfluous.





Principle of OE Rotor Spinning

With many of these techniques the fibres from the draw frame sliver are resolved into individual fibres in a processing stage prior to actual yarn spinning. In such cases the technique is generally denoted as Open End Spinning (OE Spinning).

Out of this segment OE Rotor spinning (rotor spun yarns) is currently of special significance to circular knitting, besides ring spun yarns.

In this process fibres from the draw frame sliver supply are separated from one another on an opening roller, taken over by an air stream, led through a fibre guide channel and fed to the rotor. In the revolving rotor housing the fibres lay themselves and form a ring. Out of this rotating ring the fibres are withdrawn in a plane more or less perpendicular to that of the fibre ring. The rotation of the rotor acts on the fibres in the form of twist when they just leave the fibre ring plane. This leads to a consolidation of the fibres amongst one another, i.e., to the formation of a yarn. This yarn is led away from the rotor area and is subsequently wound on a cylindrical bobbin to form a cross-wound package. The yarn obtains "real" twist. As a result of the fibre-yarn geometry during twist insertion the fibres do not have the idealized heliocoidal configuration as in a ring yarn. Every now and then fibres also coil themselves on the yarn across the longitudinal yarn axis. These places are called wrappers. A further reference is made to them later in a direct comparison between rotor and ring yarns.

Rotor spinning has established itself so far in short staple spinning. The accent lies here in the coarse count range (3 N_e to 30 N_e or 20 tex to 200 tex). Due to improvements in the technique and machine construction, combined with the use of combed slivers, count up to 42 N_e are available in good quality. Even finer counts are not only being aimed at, but are also being presented to some extent.

In short staple spinning OE rotor spinning raises performance at this stage by about 5 to 6 times as compared to ring spinning.

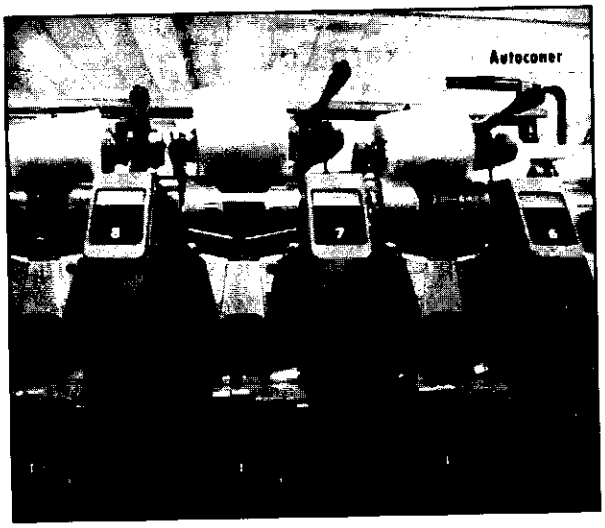
Ring Yarn

Rotor Yarn

Autoconer

The quantity of yarn on spinning bobbins or cops is small compared to the package needed for efficient at knitting and weaving. The primary purpose of the winding process is to transfer yarn from small spinning packages to large packages, which yield more efficient downstream processing.

Autoconer is a modern winding system. It is an auto coning system. By this machine we can produce a cone with required length or weight from a number of small size spinning bobbins those are produced by the ring-spinning machine without any knot. Splicing system is used in this machine. It is a fully automatic winding machine. The knitted yarn is also lubricated (waxing by paraffin wax) in this machine. In addition, all types of faults even thick places, colour materials etc. of the yarn are cleaned by this machine.



Yarn conditioning or Heat setting and Packing

Heat setting is doing in one kind of chamber. This chamber is heated at a certain temperature (60^0C) normally by steam. The yarn is conditioned in this heated chamber at a certain time (40 to 50 min.) to set the yarn twist. After heat setting these cones are packed by the polythene paper in a cartoon with a certain number normally 24 cones of 2.08 kg each for knitted yarn. Total weight of the package is 50kg. But for woven yarn total weight of the package is 100lbs. Finally these cartoons are shifted to produce fabric and so on.

Cones those are ready for heat setting

Heat setting chamber