

WOLLO UNIVERSITY KOMBOLCHA INSTITUTE OF TECHNOLOGY

Yarn manufacturing practical- I

Fibre

Any raw material that has hair like appearance or has a tapered elongated shape is called as a fibre. The fibre has a length that is at least one thousand times than its thickness. This high ratio of length to its thickness is responsible for its peculiar hair like appearance.

Fibres occur naturally or they can be artificially produced by using chemicals. Not all the fibres are suitable for the production of textile goods i.e. yarns and fabrics.

Textile Fibre

A textile fibre is the basic unit of raw material for making a yarn. The textile fibres must have a suitable length, pliability, fineness and strength that is necessary for their conversion into yarns and fabrics. A fibre having an extreme length is called as a filament.

Yarn

Yarn is a continuous strand composed of either natural or manmade fibres or filaments and is used in weaving and knitting to produce a cloth.

OR

A yarn is defined as a product of substantial length and relatively small cross-section consisting of fibres and / or filament(s) with or without twist.

(Textile Institute)

Spinning

Spinning may be defined as the process of converting fibres and / or filament(s) into a yarn.

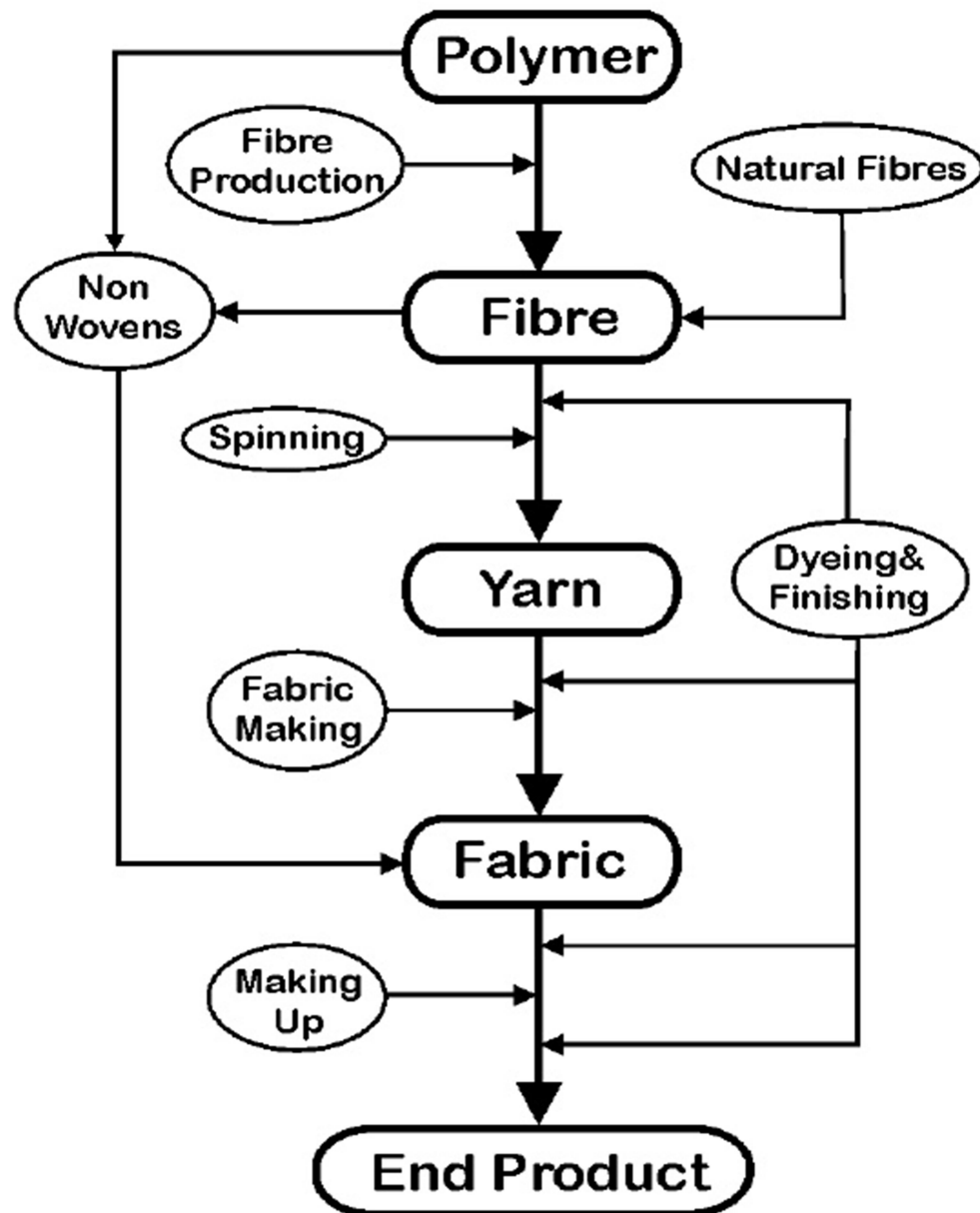
In the production of manmade fibres, the extrusion of the fibre forming liquid through the spinnerets followed by hardening of these liquid jets into solid filaments is called as the process of spinning.

The meaning of the term spinning in this case may be completely different from that used for natural fibres. Generally we can define spinning as a process that produces a yarn as its final product. The spinning of manmade fibres can be carried out by three different methods:

- (i) Wet Spinning.
- (ii) Dry Spinning.
- (iii) Melt Spinning.

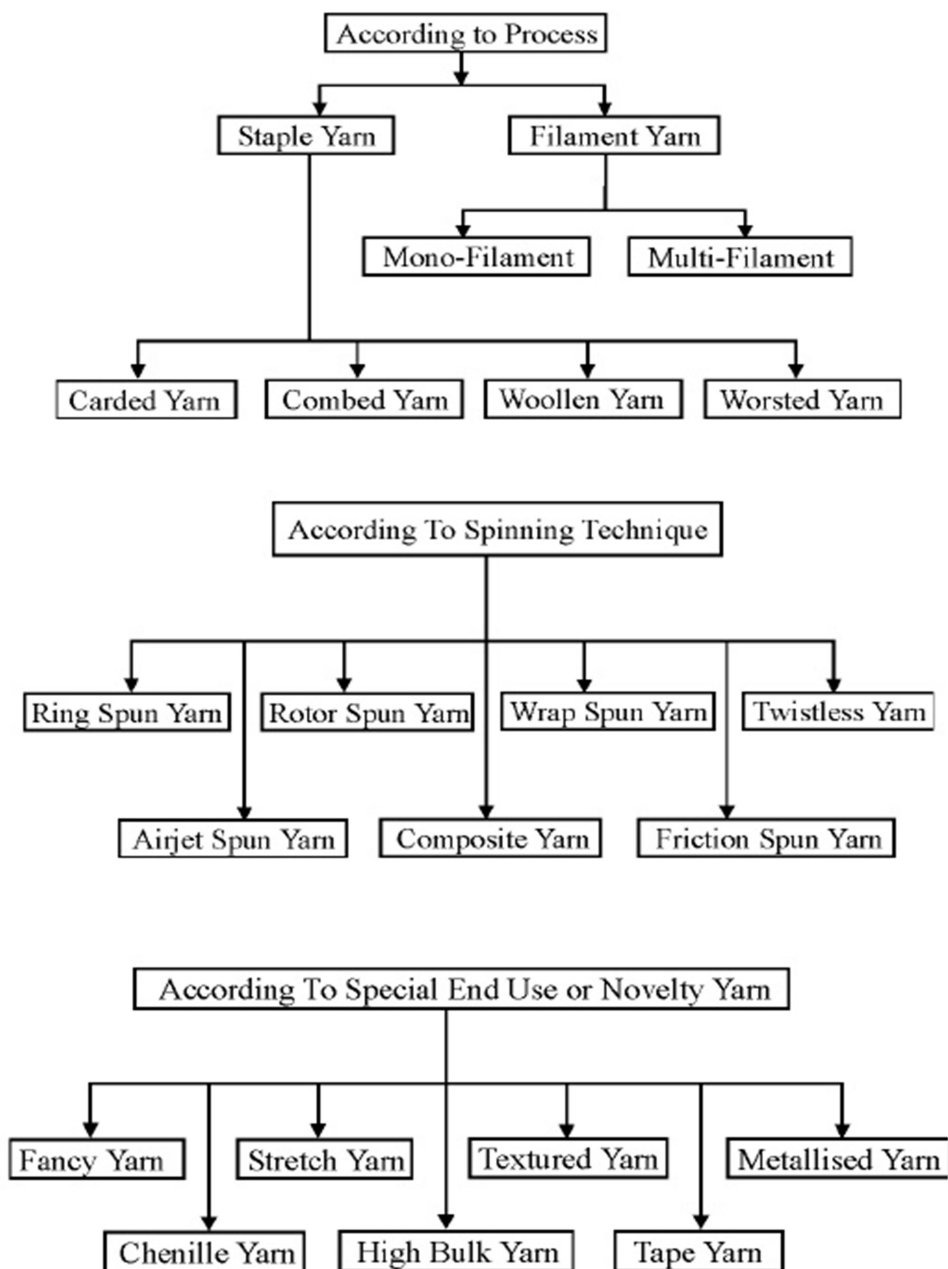
These different types of spinning methods are used based on the properties of the fibre forming substance. For example in order to spin Viscose Rayon, wet spinning is used and for Nylon we use the melt spinning. Some fibre forming substances can be spun by using more than one type of the above mentioned spinning techniques.

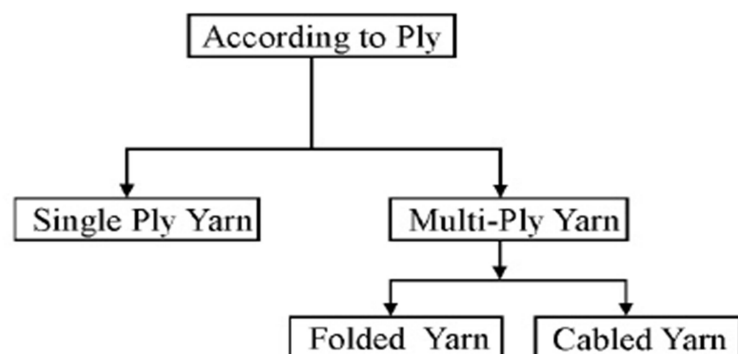
The Making of a Textile Product



Yarn Classification

There is no limit of the range of yarns that can be produced by various types of spinning processes. So it is difficult to classify various types of yarns on a single basis. Yarns can be classified on various grounds.





Fibre Properties That Can Influence Spinning

In general there are numerous fibre properties that are important to consider as these properties have a large influence on the final end product produced from it. It is also important to know every detailed fibre property because it helps us to decide the type processes that should be used for a particular fibre. However strictly speaking from spinning viewpoint the most important fibre properties that determine the spinning ability are:

- (1) Fibre Staple Length
- (2) Fibre Fineness
- (3) Fibre Strength

(1) Fibre Staple Length

Length of the fibre is the most important property that determines the quality and value of the fibre and it also determines its spinning ability. Most natural fibres have a length ranging from $\frac{1}{4}$ " to about 3". But the silk fibre made by silkworm is in a continuous filament form that can have a length of up to 2 kilometres. Apart from silk the all the natural fibres are valued from their staple length, greater the staple length greater will be their value. The staple length of the natural fibres obtained from a same source can vary. So the actual staple length given to the fibre is the length of the majority of the fibres in a lot.

On the other hand the synthetic fibres can have unlimited length in a filament form or they can be cut into a desired staple length. This is true because they are produced chemically in laboratories. Synthetic fibres either in filament or staple form will have perfect uniformity of length among themselves.

Staple length of fibres play important role in their conversion to a yarn. In general the longer the individual fibres easier it is to convert them to yarn due to the fact that long fibres will have to overlap at less frequent points as compared to short fibres and that is the reason that longer fibres can easily be spun into a yarn with less twist. Furthermore it takes less twist to convert long fibres into a yarn as compared to short fibres.

(2) Fibre Fineness

The fineness of the fibre is also an important parameter that controls spinning ability of the fibres to be converted into a yarn. Finer the individual fibres are, the finer the yarn can be made out of it. A yarn spun with finer fibres will have more number of fibres per unit cross-section as compared to a yarn having coarse fibres. This considerably increases the cohesion among the fibres within the yarn. Also the fine fibres tend to be more flexible and pliable than the coarse ones, which enables them to be spun more effectively into a yarn.

The measure of fineness of the fibres that is how thick or thin they are, is expressed in terms of fibre count. The direct method of measuring fineness or the count of the fibre is to express the thickness or diameter of the fibre in terms of microns, where 1 micron = 0.001 mm.

More practically, the count of the fibre is expressed in terms of mass per unit length i.e. the linear density. The linear density is expressed in terms of milligrams per kilometer (millitex unit), grams per kilometer (Tex unit), grams per 9000 metres (denier unit). Sometimes the mass per unit length is also expressed in grams per centimeter (usually in 10^{-8} grams / cm).

(3) Tensile Strength

The tensile strength of a textile fibre is the ability of a fibre to resist a stretching load when applied in the longitudinal direction. Whenever a pulling or a stretching load is applied to a textile fibre, it starts elongating. As the load applied to it gradually increases, a point comes when the fibre is no longer able to resist that load and it breaks. In this way the tensile strength of a fibre is found out. The tensile strength of a fibre is also called as the breaking load i.e. the load under which the fibre breaks.

In case of a single fibre, the strength of the fibre is better expressed in terms of tenacity. Tenacity can be defined as the ratio of the breaking load to the mass per unit length and is also a measure of specific stress at break.

$$\text{Tenacity} = \text{Breaking Load} / \text{Mass per unit length}$$

Tenacity is usually expressed in grams per tex, grams per decitex, grams per denier, centiNewton per Tex (cN/Tex).

It may be noted that two fibres with the same tenacity can have different tensile strength depending upon their densities or cross-section area.

The maximum achievable strength of the yarn is dependent upon the strength of individual fibres.

Yarn Dimensions

There are number of parameters that can describe a yarn, however following are the most important yarn properties:

- (1) Yarn Count
- (2) Yarn Twist
- (3) Yarn Strength

(1) Yarn Count

The yarn count or the yarn number is the relationship between the mass and the length of the yarn. Yarn count or yarn number actually describes the linear density of a yarn i.e. mass per unit length. In simpler words, the yarn number is the measure of thickness of yarn. There are two types of yarn numbering systems :-

- (i) Indirect System
- (ii) Direct System

(i) Indirect System

The indirect counting system is also known as the English counting system. It is an old system of yarn counting or numbering and is only used for natural fibres like cotton, jute, wool, flax, etc.

This system is called as indirect because here the yarn count has an indirect relationship with its weight. Which means that as the count increases, the yarn becomes finer.

In this system, the weight is kept constant while the length is variable and the number of hanks that weighs a unit weight gives the indirect count.

$$\textbf{Indirect Count = Length / Weight}$$

The most commonly used Indirect numbering systems are :-

- (a) Cotton System
- (b) Metric System or Continental System

(a) Cotton System

The Cotton count may be defined as the number of hanks per pound. Where one hank is a specific length of a yarn, for cotton fibres, it is 840 yards.

$$\textbf{Cotton Count = Number of Hanks / 1 Pound}$$

Although this Counting system can be used for many natural fibres, but still it is known as cotton system because it is mostly used for cotton fibres.

The hank length for different fibres is different depending upon the nature of the fibre. Different hank lengths for different fibres are given below :-

Nature of Fibre	Hank Length
Cotton	840 Yards
Spun Silk	840 Yards
Wool	256 Yards
Worsted	560 Yards
Linen	300 Yards
Jute	14400 Yards

(b) Metric System or Continental System

The Continental system is similar to cotton system and can be defined as the number of hanks per kilogram. Here the hank length is fixed at 1000 metres.

$$\text{Continental Count} = \text{Number of Hanks} / 1 \text{ KG}$$

(ii) Direct System

The direct numbering system is also called as French numbering system. It is a modern counting system which can be used for both natural and manmade fibres. This system is called as the direct system because here the yarn count has a direct relationship with its weight and is given by :-

$$\text{Direct Count} = \text{Weight} / \text{Length}$$

In the direct system, the length is kept constant, while the weight varies. Since the yarn has a direct relationship with its weight therefore, as the count increases, the yarn becomes coarser.

There are many direct numbering systems, the most widely used are :-

- (a) Denier
- (b) Tex
- (c) Grex

(a) Denier

Denier count is the number of grams per 9000 metres of a yarn.

$$\text{Denier Count} = \text{Number of Grams} / 9000 \text{ Metres}$$

It means that the weight of 9000 metres of yarn gives the Denier count.

(b) Tex

Tex count is the number of grams per 1000 metres of a yarn.

$$\text{Tex Count} = \text{Number of Grams} / 1000 \text{ Metres}$$

It means that the weight of 1000 metres of yarn gives the Tex count.

(c) Grege

Grege count is the number of grams per 10,000 metres of a yarn.

$$\text{Grege Count} = \text{Number of Grams} / 10,000 \text{ Metres}$$

It means that the weight of 10,000 metres of yarn gives the Grege count.

Conversion Factor

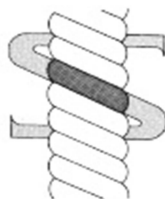
The indirect or English number can be converted into direct or French number by using the following relations :-

- (1) Cotton Count x Tex Count = 590.5
- (2) Cotton Count x Grege Count = 5905
- (3) Cotton Count x Denier Count = 5315
- (4) Denier Count = 9 x Tex Count

(2) Yarn Twist

The short staple fibres are always twisted together during the process of spinning to produce a yarn. The twist is actually given to bind the fibres together as a yarn and to give yarn strength. The amount of twist not only directly affects the strength of the yarn; it also affects lustre, abrasion resistance, handle, absorbency and flexibility.

The twist during spinning is inserted by rotating the fibre strand in either clockwise or counter clockwise direction. The direction of the twist is defined by using the letters 'S' and 'Z'. The 'S' twisted yarn is the one in which the direction of the twist or the spiral of the yarn is parallel to the centre bar of the letter 'S'. Similarly the 'Z' twisted yarn has its twist direction parallel to the centre bar of the letter 'Z'. A spindle rotating counter clockwise will produce 'S' twist while the spindle rotating clockwise will result in 'Z' twist.



S-Twisted Yarn



Z-Twisted Yarn

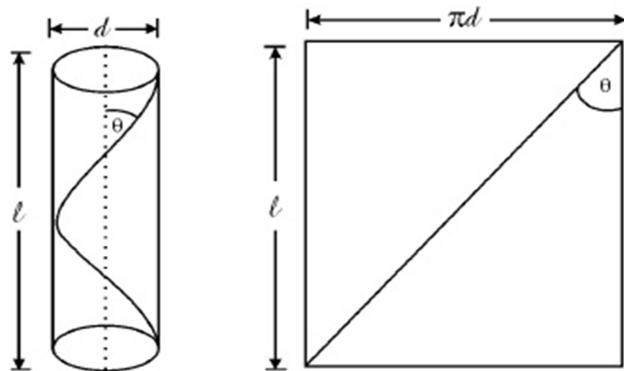
The direction of the twist is very important in folded and cabled yarn where the direction of the twist of the individual thread and the direction of twist of folding and cabling affects the properties of the resultant yarn. The direction of twist of the yarn can also affect some woven fabric structures like twill weaves.

The majority of the cotton spun yarns are 'Z' twisted this is due to the fact that most of the spinning equipment are designed for producing 'Z' twisted yarns because such an equipment will favour a right-handed person as he does the necessary repairing and maintenance of machine parts.

The amount of twist in a yarn is expressed in terms of turns per unit length usually in turns per inch (tpi), turns per centimetre and turns per meter. The yarn with a low twist will be weaker, softer and bulkier. In general to hold and to give strength to short fibres more twist is required.

As the degree of twist in a yarn increases the strength of the yarn also increases. However when the amount of twist is further increased beyond an optimum value then on further increase of twist, the strength of the yarn decreases. This is due to the fact that with an excessive twist, the fibres tend to be more perpendicular than parallel to the length of the yarn i.e. they lose their linear orientation and also because with an excessive twist fibre breakage occurs.

Assuming the yarn as a perfect cylinder, consider a yarn having a length (L) and diameter (d) with only one turn of twist inserted into it. If the yarn is cut from the centre and is laid flat then it would look like a rectangle as shown below:



It is very important to establish a relationship between the helix angle (θ) and the tpi inserted in a yarn. The helix angle (θ) depends upon the amount of twist present in a yarn. With a change in the value of tpi, the helix angle (θ) will also change.

From the above figure:

$$\tan \theta = \pi d / L$$

But

$$L = 1 / \text{tpi} \quad \text{and} \quad d = \frac{1}{2.8 \sqrt{N c}}$$

So

$$\tan \theta = \frac{\pi}{2.8} \times \frac{\text{tpi}}{\sqrt{N c}}$$

This equation shows that the helix angle (θ) is also related to the count of the yarn. If the helix angle (θ) is to be kept constant, the ratio of tpi and yarn count should also be kept constant. In other words to spin yarns of various different counts but with the same twist characteristics this ratio should remain the same.

Which means that twist or tpi in a yarn is directly related to the fineness or count of the yarn. Fine yarns would usually require a higher value of tpi than coarse ones.

To calculate the amount of optimum tpi required for various counts of yarns a term called as twist multiplier comes into play. Twist multiplier (TM) is defined as the ratio of the tpi to the square root of the cotton count.

$$\text{Twist Multiplier} = TM = \frac{tpi}{\sqrt{N_c}}$$

Different types of yarns according to the end usage are spun with different values of TM. For example knitted yarns or hosiery yarns are spun with a TM of 2 to 3, weaving yarns with a TM of 3 to 5 and hard twisted crepe yarns are twisted with up to a TM of 7. Too much twist makes the yarn hard, brittle and cause snarls in the yarn and becomes hard to knit and weave.

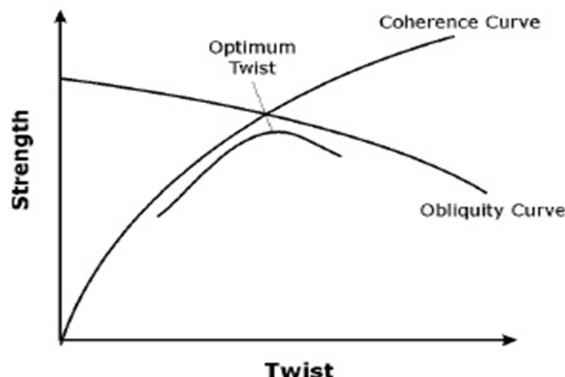
(3) Yarn Strength

All the staple yarns consist of fibres twisted together. The purpose of twisting is to bind the fibres together so as to strengthen the yarn. If a load is applied to a yarn with a low twist then that yarn may break easily. This breakage may not be due to the breakage of fibres but because of the slippage of the fibres. As the amount of twist increases, the level of cohesiveness among the fibres will also increase making the yarn stronger and more compact. Such a yarn would require a bigger load to break it.

So the major source of strength to the yarn is provided by the twist. As the twist increases, the strength of the yarn also increases. However this is only true up to a certain limit of twist called as the optimum twist. Beyond the optimum twist, on further increase in twist will reduce the strength of the yarn. This is because of the two factors:

- (i) Excessive twist causes obliquity in the fibres and the fibres tend to lie more perpendicular than parallel to the length of the yarn i.e. they lose their linear orientation.
- (ii) Secondly with an excessive twist fibre breakage occurs.

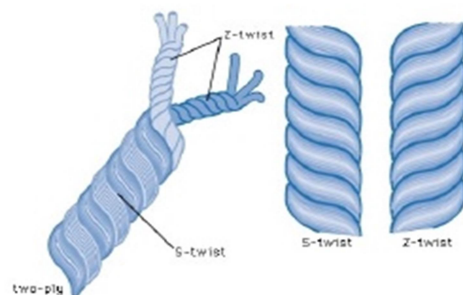
The relationship between the yarn strength and the twist is shown by the following graph:



Folded & Cabled Yarns

Folded Yarns

Folded or plied yarns are spun from two or more single yarns by twisting them together. Two fold or two ply yarn for example is composed of two single yarns and three ply or three fold yarn is composed of three single yarns. Depending upon twist direction two methods are used to make a plied yarn:



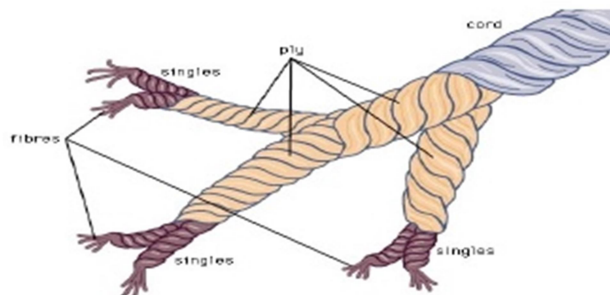
- (i) All the individual single yarns are twisted in one direction and are then combined and twisted in the opposite direction to form a uniform and soft folded or plied yarn.
- (ii) All the individual single yarns are twisted in one direction and are again combined and twisted in the same direction to form a hard and less flexible folded or plied yarn.

Uses of Folded Yarns

- (i) Folded yarns are used for heavy industrial fabrics where extra strength is needed.
- (ii) By the process of folding, a very coarse yarn that is impossible to make on ordinary spinning machines can be made.
- (iii) Folded yarns made from very fine fibres are used in delicate looking sheer fabrics.

Cabled Yarns

Cabled or Corded yarns are produced by twisting two or more plied or folded yarns together.



Cabled or Corded yarns can be produced by different combinations of twist directions:

- (i) Usually cabled yarns are made with the final twist usually applied in the opposite direction of the ply twist.
- (ii) Cables or cords may follow an SZS form, with S-twisted singles made into Z-twisted plies that are then combined with an S-twist, or may follow a ZSZ form.
- (iii) Cabled or corded yarn may also follow an SSZ or a ZZS pattern.

Uses of Cabled or Corded Yarns

- (i) Corded yarns may be used as rope or twine.
- (ii) They may also be made into very heavy industrial fabrics
- (iii) Cables made from extremely fine fibres are used to make sheer dress fabrics.

Count of Folded and Cabled Yarns

In order to find out the count of the folded and cabled yarns we use the following formula :-

For Direct Numbering system :-

$$\text{Final Count} = C_1 + C_2 + C_3 + C_4 + \dots$$

Where, $C_1, C_2, C_3, C_4, \dots$ are the counts of the threads out of which the folded yarn or cabled yarn is made.

For Indirect numbering system :-

$$1/\text{Final Count} = 1/C_1 + 1/C_2 + 1/C_3 + 1/C_4 + \dots$$

Where, $C_1, C_2, C_3, C_4, \dots$ are the counts of the threads out of which the folded yarn or cabled yarn is made.

For using these formulas, the count system of each yarn in the folded or cabled yarns must be the same.

Variables in Yarn Production

Most generally yarns can be classified into continuous filament yarns made out of manmade raw material and short staple yarns produced from natural fibres. However within these two categories endless varieties of yarns can be produced because there are so many variables involved in yarn production. Some of the variables are listed below:

- (1) Type of fibre(s) and / or filament(s) used in an individual yarn.
- (2) Dimensional and physical characteristics of the fibre or filament used in a yarn e.g. fineness, cross-sectional shape, crimp, density, etc.
- (3) The mechanical properties of a fibre or filament e.g. tensile strength, tenacity, extensibility, elastic properties, etc.
- (4) The general properties of a fibre or filament e.g. frictional properties, moisture regain, thermal properties, dimensional stability, resistance to micro-organisms, static properties, electrical properties, colour, ageing etc.
- (5) Chemical properties of a fibre or filament e.g. resistance to acids, alkalis, dry cleaning agents and other chemicals.
- (6) The method of yarn production e.g. carded system, combed system, woollen system, worsted system, etc.
- (7) Method of final yarn formation e.g. ring, rotor, wrap, core, air jet & friction spinning, etc.
- (8) Component of the yarn e.g. 100% natural fibres, 100% manmade fibres, blend of natural fibres with manmade fibres, blend of natural fibres with filaments, etc.
- (9) The linear density i.e. the count of the yarn and the level of twist (twist multiplier).
- (10) Cross-section of the yarn e.g. circular, elliptical, flat, textured, etc.
- (11) Ply of the yarn whether the yarn is single-ply or multi-ply.

As far as natural fibres are concerned, they have typical properties depending upon the group to which they belong. For example cotton, flax, jute, etc all are cellulosic fibres on the other hand wool, silk, mohair, etc all belong to proteinic fibres. There is nothing much can be done to alter the basic properties of these fibres. These properties also vary from lot to lot within the same category. On the other hand in manmade fibres, most of the properties can be controlled to a great extent and precision. They can both occur in filament and short staple form of desired length.

Consequently the yarn properties made of natural fibres are dependent on the basic natural properties of the fibre. However in case of manmade yarns properties of the fibres can be modified to meet the requirements of the end use of the yarn.

General Principles of Short Staple Spinning

All short staple yarn spinning systems make use of the following basic principles:

(1) Mixing

The term mixing is applied for combining or blending more than one mass of fibres into a single homogenous mass. Since all the natural fibres vary from one another from region to region, field to field and even from bale to bale, it is necessary to mix them well so that the final end product i.e. the yarn may be homogenous and of consistent quality.

(2) Blending

Usually blending refers to the mixing and combining two or more than two fibres of different origins. For example cotton fibres with polyester. The purpose of blending is to achieve desired properties of both the components of the fibres in a yarn which otherwise is unobtainable from a single component. For example strength, crease resistance, colour, price, moisture absorption, drying properties, etc.

Just as mixing, blending should also be done thoroughly so that a homogenous yarn may be produced out of the component fibres.

(3) Opening

The raw fibres for easy transportation are highly compressed into bundles called as bales. Before effective spinning can be carried out, this compressed form of fibres must be separated from one another. Opening refers to mechanical separation of fibres from one another. The opening is carried out gradually in steps. In the first step the bale of fibre is broken down into small tufts then later on at various stages of spinning these tufts are further broken down into individual fibres.

(4) Cleaning

All the natural short staple fibres have some amount of natural impurities in it. These impurities have to be removed before fibres are converted into a yarn. On the other hand the short staple manmade fibres just require opening but no cleaning.

The amount and type of cleaning required for a particular lot of fibres depends upon size and amount of impurities present in it. Greater the trash content in fibres greater number of cleaning points are used during various stages of the spinning process. Typically cotton bale contains about 5 to 10% impurities and about 3.5 to 7 % cleaning is obtained during initial opening and cleaning.

Cleaning is generally associated with opening. As the fibre opening takes place, the impurities also get separated and removed. Greater the degree of opening, greater cleaning may be carried out.

(5) Fibre Separation

The fibre separation is the further opening of the small tufts that have been initially opened up into an individual fibre form. This happens at the carding machine. By fibre separation a further up to 1% waste can be removed.

(6) Fibre Regularising

Fibre regularising means the reduction in the variation of the mass per unit length of the fibre material. Regularising is very important to produce a regular and a more consistent quality of a yarn. Fibre regularity takes place at the drawing frame.

(7) Fibre Alignment

Along with the improvement of the fibre regularity, the alignment of the fibres also improves at the draw frame. Fibre alignment means the straightening of the fibres and making them parallel to the axis of the sliver.

(8) Drafting

Drafting is drawing out or attenuation of the fibre material into a desired fineness or count of a yarn. In ring spinning system drafting is done in two stages one at the roving frame and other at the ring frame.

(9) Twisting

Twist plays a vital role in the final formation of the yarn. The purpose of giving twist is to bind the fibres together as a yarn and to give strength to the yarn. The major twisting takes place at the ring spinning frame or at the final stage of spinning.

Cotton Impurities

Any foreign material other than fibres is classified as impurities. Not only the quality and the price of fibres depend upon the amount of impurities present in the fibres, also the subsequent processes depend on it. Greater the impurities are more efforts have to put in to remove it. The removal of the impurities also results in the loss of useful fibres. Impurities are also found in the manmade fibres however the level is significantly low as compared to impurities in natural fibres.

The impurities in cotton fibres can be classified into:

(1) Seed

Seed impurity is the largest type of impurity present in raw cotton and it includes un-ginned seeds with fibres attached to it, ginned seeds and parts of seeds.

(2) Chaff

The chaff is the vegetable fragments consisting of leaf particles, bract, shale and stalk of the cotton plant. Bract is a small type of a leaf that grows beneath the cotton boll and shale is the silvery interior lining of the cotton boll.

(3) Dirt

The dirt impurity includes soil and sand particles that may be added from the cotton fields due to mishandling of the fibres and also the cotton fibres pick up dust and sand if they are transported by open trucks.

(4) Micro-dust

The micro-dust includes very fine particles of chaff, dirt, small fibre fragments and spores of mildew. These particles are extremely small and are often a fraction of the fibre diameter. They generally get embedded around the natural wax of the cotton fibre.

(5) Abnormal Impurities

The abnormal impurities are very rare however when found in the cotton fibres, they can cause serious problems. These impurities include pieces of stones, pieces of iron, cloth fragments, foreign fibres such as jute, polypropylene, etc (that may be included due to the bagging of cotton fibres made up of these fibres), grease and oil (from machine harvesting or ginning), tar and coal (from the air while the cotton fibres are transported openly), small pieces of wood, etc.

The term trash is applied to all of these impurities present in the raw cotton. The total trash content of cotton fibres ranges from 1% to 10% of the total weight of the cotton fibres. The amount of trash content directly determines the amount of cleaning required.

Removal of Impurities

The removal of impurities is associated with the opening of the fibres and is carried out in stages during the spinning process. Initially the impurities are removed in the blow room with the very basic opening of the larger tufts of fibres into smaller tufts. Then further at the carding machine due to fibre separation, more impurities are removed. The blow room mostly removes the seed and chaff while the carding removes the dirt and microdust. Greater the impurities present in fibres more opening and cleaning is required. However with more severe opening and cleaning, expensive fibres can be damaged or they can be lost during the process.

Methods of Opening & Cleaning

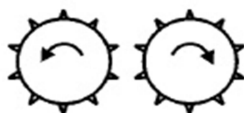
The mechanical techniques or methods used for the opening and cleaning of the cotton fibres are:

(1) Spiked Surfaces

This action consists of plucking and gripping the mass of cotton fibres between two sets of spiked surfaces moving in opposite directions. This action opens the fibres and does some cleaning as well.



Tearing Up



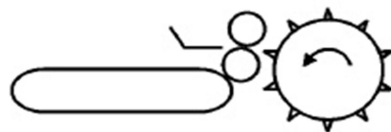
Plucking Up



Plucking Out

(2) Beaters

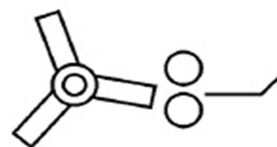
The term beater in spinning is generally referred to a revolving drum having blades, spikes or pins mounted on its surface. The fibres are fed and subjected to the surface of the beater with the help of air currents or by using a pair of rollers. When the surface of the beater strikes the fibre mass, it plucks or tears the fibres and transports the opened fibre to the next stage. During this opening, the trash being heavier falls down and is collected below the machine.



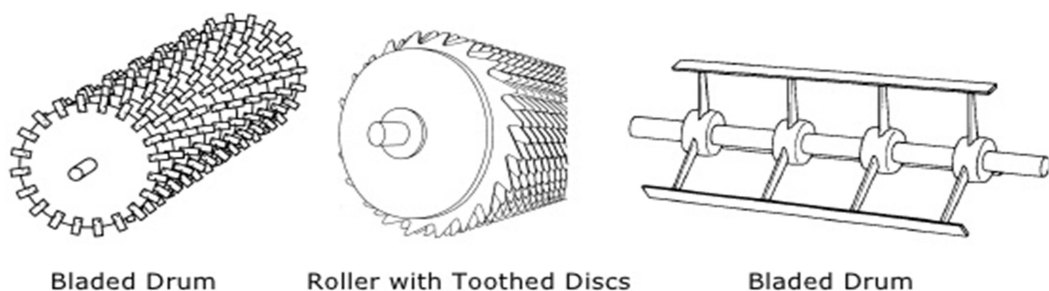
Plucking Out



Tearing Out

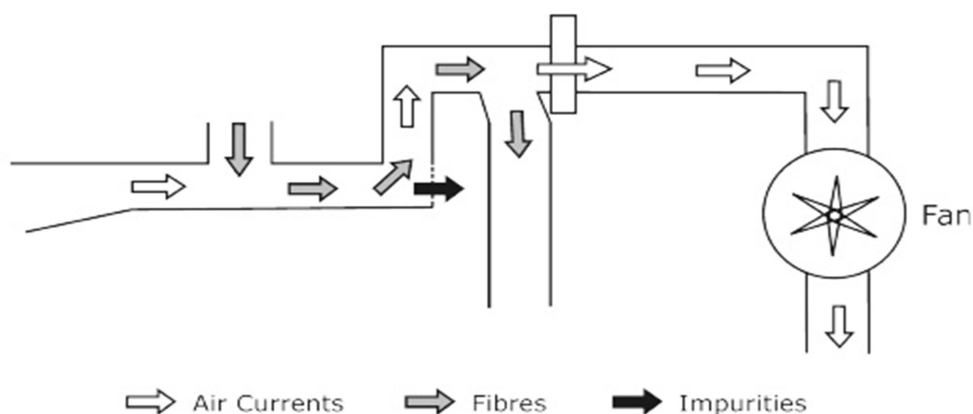


Beating Out



(3) Air Currents (Pneumatic Action)

Lighter impurities like dust and micro-dust can not be effectively removed from the fibres by using either the spiked surfaces or beaters. These impurities can be removed by passing the fibres over the perforated grids where the air currents can draw off the dust in the fibres.

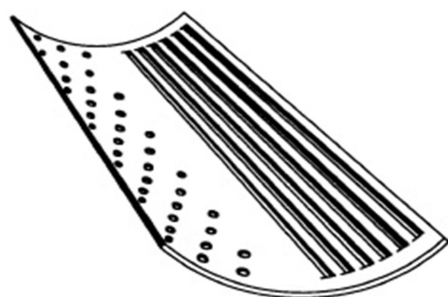


All the above and majority of the operating devices in the blow room machinery are opening devices when they are used alone. However these very same opening devices can also work as cleaning devices if they are worked in cooperation with cleaning apparatus such as grids and special machine covers.

The following elements can be used in grids:

- (i) Slotted Sheets
- (ii) Perforated Sheets
- (iii) Triangular Section Bars
- (iv) Angle Bars
- (v) Blades

These elements can either be used alone or in combination with each other. For example, the perforated and slotted sheets were widely used and placed under the cards but now their use is diminishing. Same is the case with the blade grids that were used in combination with triangular bars grids.



Perforated Sheet

Slotted Sheet



Triangular Bars



Angle Bars



Knife Blades

The angle bars are very robust but they tend to create fibre blockages. So Today in the modern cleaning techniques, either the triangular grid bars or knife blades are used alone for the most efficient waste removal.

The impurities and the fibres fall through the gap of the grids and are collected in a special waste chamber of the machine which is placed under the grid. In old machinery this waste has to be manually removed periodically however in the latest opening and cleaning systems pneumatic waste removal systems are used.

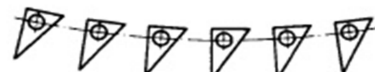
Grid Adjustments

The grids can be in one, two or three parts so it can be adjusted as a unit or in individual sections. Three basic adjustments are possible.

- (i) Distance of the complete grid to the beater.
- (ii) The distance or the gap between the adjacent grid bars.



Closed Gap Setting



Open Gap Setting

- (iii) Angle relative to beater blade



Oblique Angle



Aggressive Angle

It is seldom possible to make all these three adjustments, generally machines are so designed that only two adjustments are possible.

Cleaning Efficiency

All openers & cleaners along with foreign matter also remove a certain amount of short fibres (also called as lint). The composite of trash, dust, fibre fragments and fibres removed is called as waste. The amount of waste removed at each stage of cotton cleaning stage should be known for evaluation and can be found out as:

$$\% \text{ age Waste Removal} = \frac{\text{Waste Removed (Kg)}}{\text{Total Fibres Processed (Kg)}} \times 100$$

The effectiveness of a machine or series of machines in a blow room to remove the trash in the fibres is expressed as its cleaning efficiency and is given by:

$$\% \text{ Cleaning Efficiency} = \frac{\% \text{ trash in raw fibres} - \% \text{ trash in processed fibres}}{\% \text{ trash in raw fibres}} \times 100$$

Factors Influencing Opening & Cleaning

The degree of opening, the degree of cleaning and the fibre loss are primarily dependent on the following factors:

- (1) The type of opening devices used.
- (2) The speed of the opening devices.
- (3) Type of feed
- (4) Degree of penetration.
- (5) Spacing of feed from the opening devices.
- (6) Type of grid used.
- (7) Area of grid surface.
- (8) Grid Settings.
- (9) Airflow through the grid.
- (10) Condition of pre-opening.
- (11) Position of the machine in the machine sequence.

THE BLOW ROOM

The blow room is the first stage or the first process in the short staple spinning. The name 'Blow Room' is given to this stage because of the air currents that are commonly used during the processing of fibres. In the blow room the fibre mass is progressively opened, cleaned and mixed. This is done by using a large number of machines. In each of these machines used in blow room if the actions are too severe or sudden then fibre damage will occur.

Functions of Blow Room

(1)**Fibre Opening:** The tightly packed fibre bales received from the ginning mills have to be opened by converting the larger fibre tufts into smaller ones and ultimately converting the smaller tufts into individual fibre form.

(2)**Cleaning:** All the natural fibres including cotton have considerable amount of impurities in them which have to be removed to produce a clean yarn.

(3)**Mixing/Blending:** The properties of the cotton fibres differ from each other from bale to bale and from fibre to fibre so in order to obtain a homogenous and consistent quality yarn, they need to be thoroughly mixed together. Sometimes in order to have a desired quality at the right price high quality cotton fibres are mixed with low quality fibres.

(4)**Preparation of feed for the next stage:** The end product of the blow room should be compatible with the next stage of spinning i.e. carding. The feed to the carding can be either given in the form of lap or in direct chute form.

Blow Room Machinery

In the blow room all the above functions have to be fulfilled for this purpose various different types of machines are used. Based on the functionality of these machines they are classified into five types:

- (1) Bale Opening Machines
- (2) Mixing Machines
- (3) Cleaning Machines
- (4) Dust Removing Machines
- (5) Recycling Machines

For these machines to perform optimally, they must be located at specific positions in the blow room line. The modern cotton blow room line can be divided into six distinguished zones.

- (1) Bale Opening Zone
- (2) Coarse Opening & Cleaning Zone
- (3) Mixing/Blending Zone
- (4) Fine Opening & Cleaning Zone
- (5) Intense Opening & Cleaning Zone
- (6) Card Feed Preparation Zone

In case the cotton has less impurities then the Zone 5 (intense opening & cleaning) may not be necessary. Furthermore the Zone 4 (fine cleaning) or the

Zone 5 (intense opening & cleaning) and the Zone 6 (card feeding) can form a single unit.

The additional operation of dust removal is not associated with any single zone; in fact dust removal is carried out at a greater or lesser extent at every machine of the blow room.

Bale Conditioning

The cotton fibres from the ginning factories are received by the spinning department in form of highly compressed bales that are wrapped by metal or plastic straps. As the bales are received these straps are cut off and the bales are allowed to condition for 24 hours in controlled temperature and between 60% to 80% relative humidity. For this purpose all the spinning mills allocate floor space for conditioning purpose.

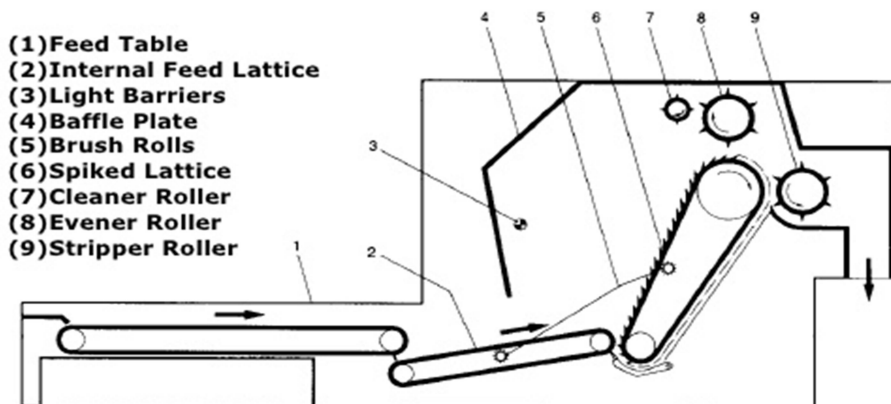
The conditioning allows the fibres to relax and maintain a temperature and moisture equilibrium with atmosphere and reduces the chance of fibre damage and inconsistency in quality.

Bale Lay Down

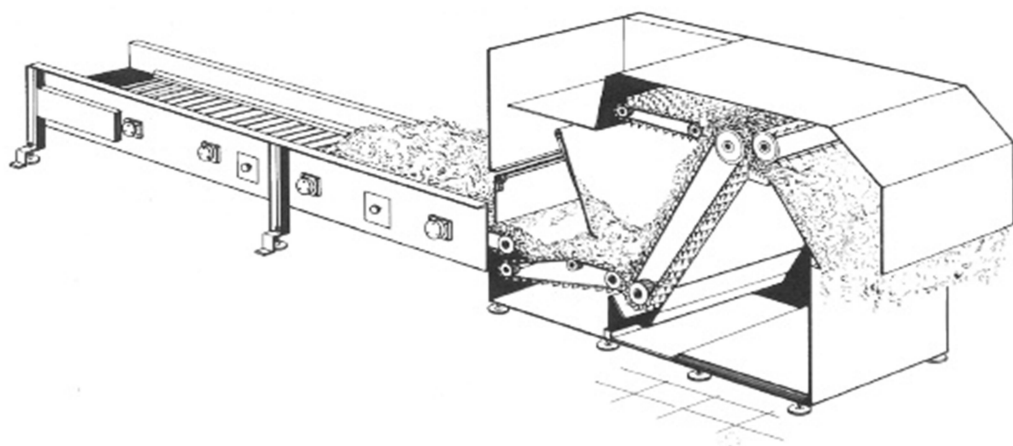
After the bales are conditioned properly they are taken to the blow room and placed in groups of special sequence for the first processing stage. This group of bales is called as bale lay down. The main aim of a proper bale lay-down is to have fibres with similar properties and spinning attributes from lay-down to lay-down so that spinning machines can be adjusted optimally and yarn of consistent quality may be produced over a longer period of time.

Zone-1 (Bale Opening Machines)

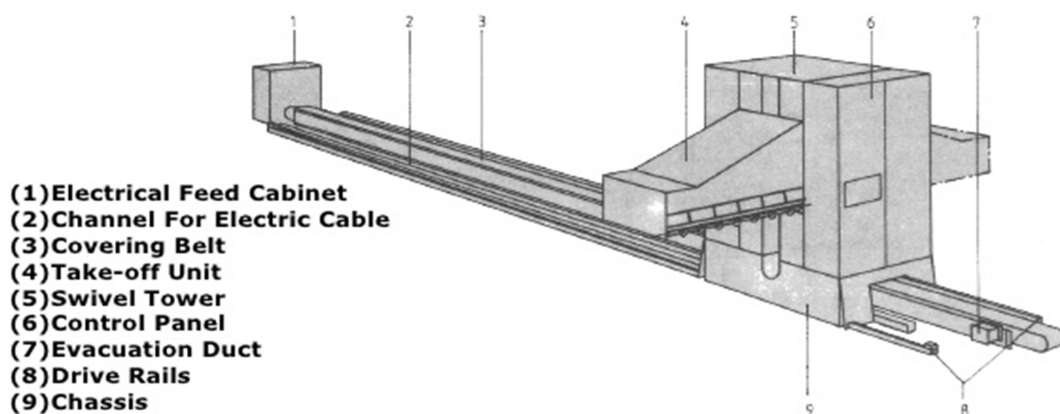
After proper bale lay-down the initial bale feeding is done either by using a parallel set of machines called as hopper feeders or by a single machine called as a top feeder. The hopper feeders have stock supply compartments which are either filled manually or by automatic machines. A cross-sectional diagram of a typical hopper feeder is shown below:



The more realistic shape of the hopper feeder can be seen in the following figure:



The hopper feeders although are still used in quite sophisticated form however they are considered to be conventional type of bale openers. They remain stationary while the raw fibres from the bales can be fed manually or by automatic machines. Nowadays the most popular and modern machine for feeding raw fibres from the bale is the top feeder. In the following Figure, the Rieter Unifloc Top Feeder is shown:

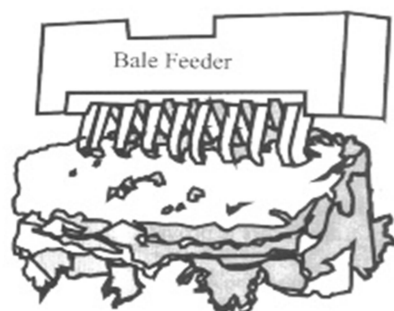


The top feeders are travelling machines that move over and past the bale layout and extract fibres from top to bottom. They have great advantage that more than one bale can be processed simultaneously to give a better long term blend. These machines are fitted with computerized control panels and they extract material from all the bales evenly. The production rates of such modern bale openers ranges from 750 kg/hour to 1000 kg/hour

The hopper feeders and the top feeders should perform the following functions:

- (i) Extract material evenly from bales.
- (ii) Open the material gently.
- (iii) Open up to smallest tufts.
- (iv) Form tufts of equal sizes.
- (v) Process as many bales as possible in a single charge.
- (vi) Easily programmable.
- (vii) Blend fibres at the start of the process.

All the bale opening machines not only feed the raw fibres but also do the tuft opening. This opening actually starts from the point when these feeders start gripping the fibres for an initial feed as shown below:



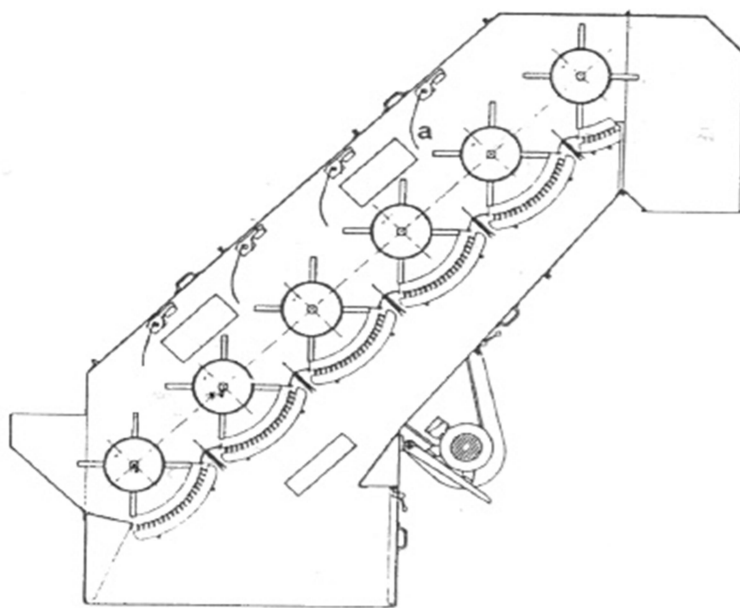
Zone-2 (Coarse Cleaning Machines)

The coarse cleaning machines directly gets its feed from the hopper feeders or from top feeders. The striking and beating elements in this zone are widely spaced and hence the opening of the fibres is also very minimal. The main purpose of these machines is to open up the mass of fibres into large tufts which are then converted into smaller tufts by using more intense opening and cleaning machines in the next zones. The machines in these zones are sometimes not even fitted with cleaning devices or even if these cleaning devices are present, they can only remove fraction of the impurities.

Different machine manufacturers have developed various types of coarse cleaning machines. The most commonly used ones are:

(i) The Step Cleaner

The step cleaner is a very standard type of a coarse cleaning machine that is produced by several manufacturers.



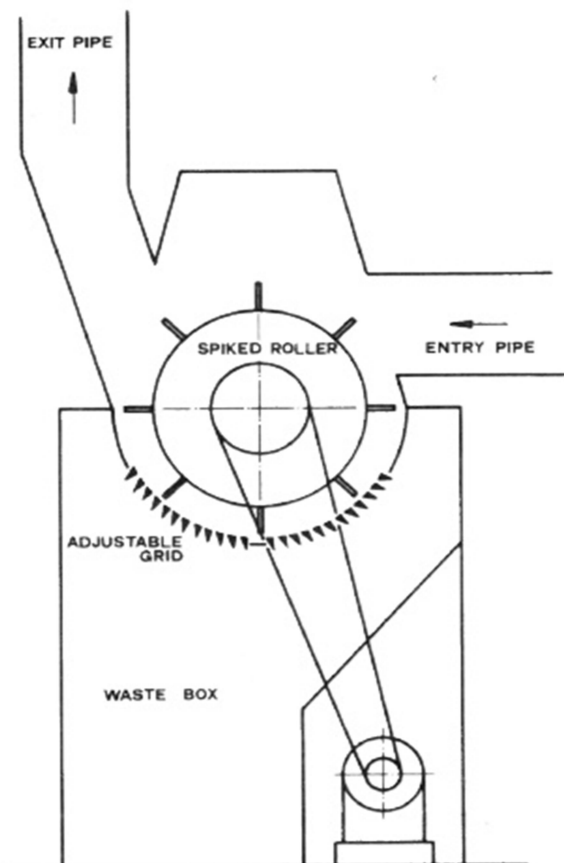
Truetzschler Step Cleaner

As the material falls into this machine it is subjected to first beater which not only does the initial opening but also transports the fibres upwards where sometimes 4 or 6 beaters are placed close to one another and inclined at an angle of 45° . The surface of these beater rollers are covered with blades or bars. The cleaning of the impurities takes place as the material continuously passes from one roller to the other with the help of grids placed beneath each of the roller. The speed of the beaters and the grids are both adjustable.

(ii) Uni-Cleaner

The uni-cleaner or the mono-cylinder cleaner relies on the use of single beater roller having its surface covered with spikes. The fibre material enters to the machine from one side due to a suction effect produced at the other side of the machine. To ensure that fibres may not pass the exit pipe untreated by the beater, following arrangement is done:

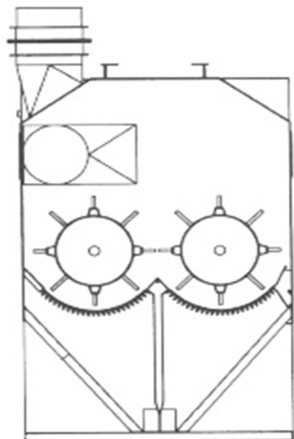
- (a) The hood of the machine around the beater is designed in three portions in such a way that the fibre mass is forced to fall back into the region of the beater after being beaten by the beater. In this way the fibres are forced to circulate the beater many a times to give required opening and cleaning.
- (b) The exit opening of the machine is kept higher than the in-feed opening of the machine that also ensures that only the smallest tufts can pass straight through but the bigger tufts are always subjected to the beater action of the beater.



Rieter Monocylinder Cleaner

(iii) The Dual Roll Cleaner

The dual roller beater is some how similar in working as that of a mon-cylinder cleaner. However in this case instead of only a single beater roller, two beater rollers of about 61 cm diameters are used. Both of the rollers rotate in the same direction and have their surfaces covered with spikes arranged in a spiral to improve passage of the material.

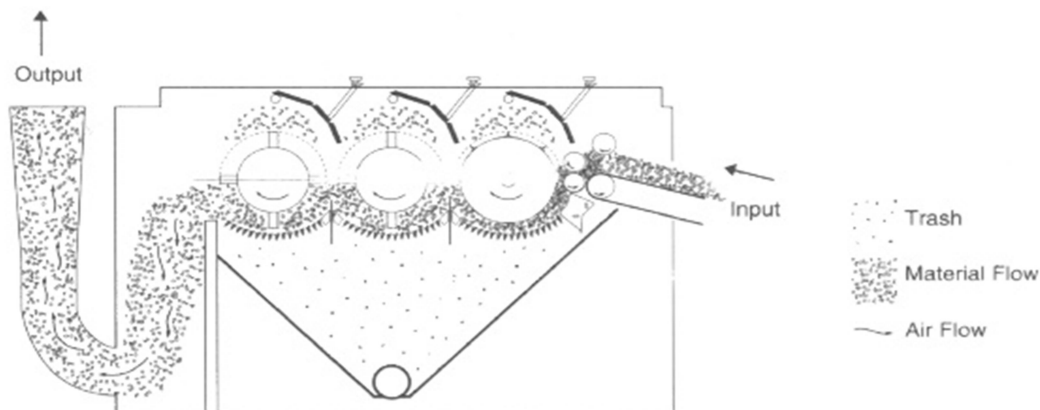


Hergeth Hollingsworth Dual Roller Cleaner

The exit opening of the machine is kept higher than the in-feed opening of the machine to ensure that only the smallest tufts can pass straight through but the bigger tufts due to weight falls down and are always subjected to the beater action of the beater.

(iv) The Three Roll Cleaner

The three roll cleaner is exactly the same in working as the dual roll cleaner. The only difference is that it has three rollers placed side by side instead of two.

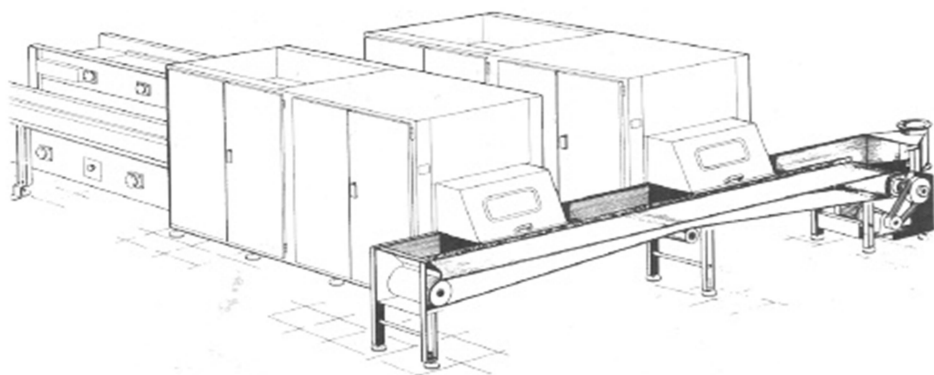


Crosrol Three Roll Cleaner

Zone-3 (Blending/Mixing Machines)

(i) The Mixing Battery

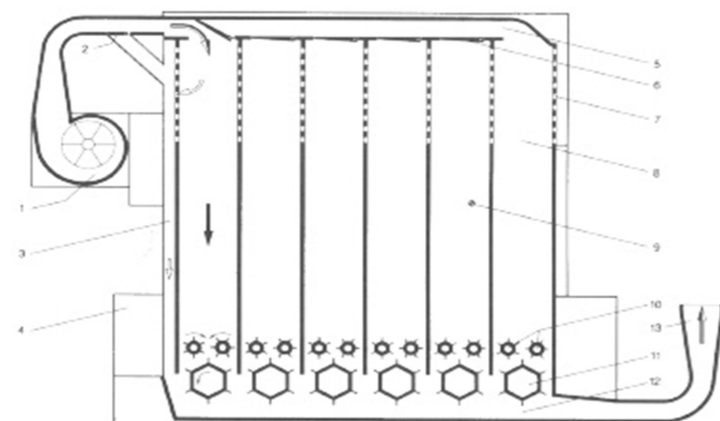
This is the most commonly used type of a mixing/blending machine that does the mixing at the start of the process. In the arrangement 2 to 6 bale openers are operated together independently. The opened fibre material from all the bale openers are fed onto the common conveyer belt.



This gives a very good mix and blend of fibres. In the latest mixing batteries each of the bale opener is equipped with electronic weighing equipment that can easily ensure correct blends of various components of fibres at a predetermined ratios e.g. example 60% Cotton, 40% Polyester.

(ii) The Multiple Mixer

This is again a very simple mixer that gives very good long term blend. The machine is composed of several (6 – 8) chambers. The fibre material is pneumatically fed from the top. All the chambers are successively and simultaneously filled and the material is removed from the bottom through a single common duct.

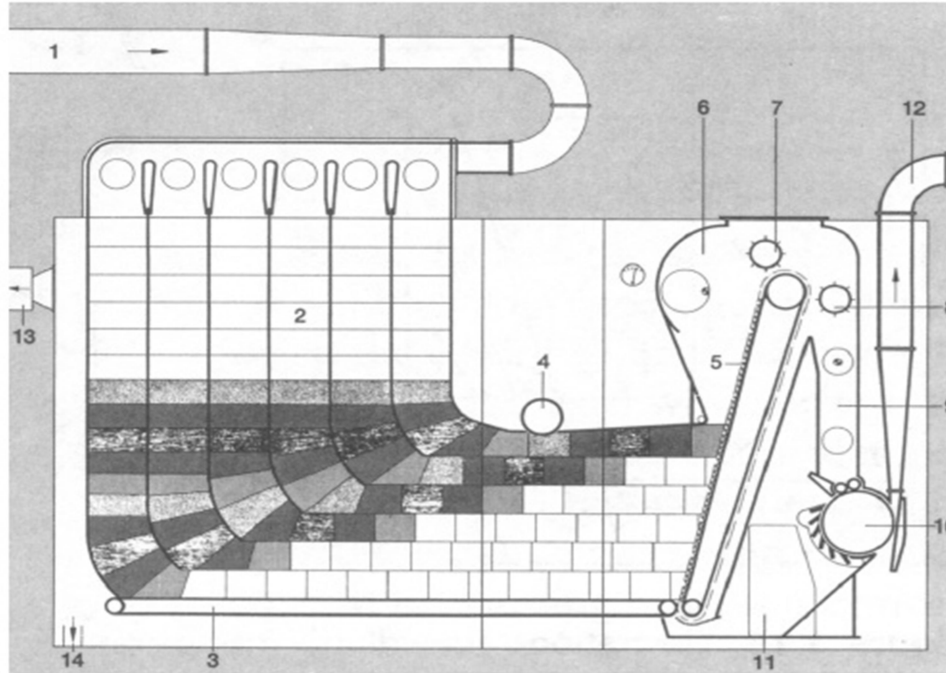


- (1) Fan
- (2) Air Bypass
- (3) Exhaust Air Duct
- (4) Pressure Switch
- (5) Feed Duct
- (6) Closing Flap
- (7) Perforated Plate
- (8) Blending Chamber
- (9) Light Barrier
- (10) Delivery Rollers
- (11) Opening Rollers
- (12) Blending Channel
- (13) Suction Tunnel
- (14) Exhaust Air Outlet

Truetzschler Multi-Mixer

(iii) The Unimix

The unimix is a combination of blending and cleaning machine and both of these two operations are carried out within the single machine.



Rieter Unimix

- | | | |
|----------------------|-------------------------|--------------------------|
| (1) Feed Pipe | (2) Filling Chambers | (3) Conveyer Belt |
| (4) Conveying Roller | (5) Upright Lattice | (6) Intermediate Chamber |
| (7) Stripper Roller | (8) Take-off Roller | (9) Filling Trunk |
| (10) Cleaner Roller | (11) Waste Chamber | (12) Fiber Delivery |
| (13) Exhaust Piping | (14) Exhaust Air Outlet | |

The machine is divided into three sections:

- (a) Storage Section
- (b) Intermediate Chamber
- (c) Delivery Section

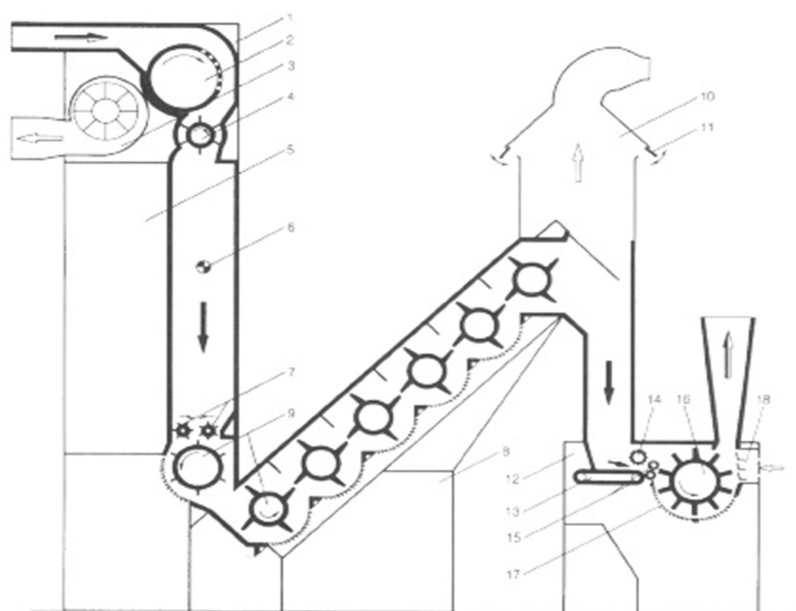
The fibres are pneumatically fed into six individual chambers of the machine. The fibres coming out of each of the six chambers are taken on a common lattice or a conveyer belt that takes the material to an intermediate chamber with the help of an inclined or upright lattice. From here the material passes through a delivery section to the next machine with the help of a pneumatic suction. In the delivery section a cleaning roller is used which does the coarse cleaning of the fibres as they are being delivered.

Zone-4 (Fine Opening & Cleaning Machines)

The Zone 4 cleaning machines although utilizes the same principles of opening and cleaning as that of the Zone 2 cleaning machines but has some differences:

- (a) The Zone 4 machines are always fed using clamp feed that is to make sure that controlled amount of fibre size and fibre quantity is fed.
- (b) The spacing of the beater with the hood of the machine and with the grids is kept finer.
- (c) Finer and more number of striking elements (pins, blades, spikes, etc) are used.
- (d) The speed of the beaters is kept higher.

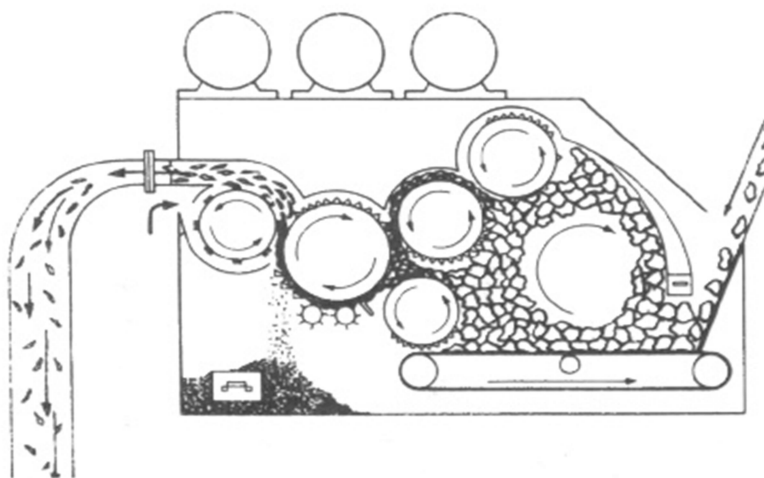
The RN Cleaner of Truetzschler as shown below is one of the most efficient and widely used fine opener and cleaner:



- | | | |
|------------------------|----------------------|--------------------|
| (1) Condenser | (2) Dust Cage | (3) Fan |
| (4) Finned Roller | (5) Feeding Unit | (6) Light Barrier |
| (7) Feed Rollers | (8) Step Cleaner | (9) Cleaner Roller |
| (10) Microdust Suction | (11) Fresh Air Flaps | (12) RN Cleaner |
| (13) Inner Lattice | (14) Pressure Roller | (15) Feed Rollers |
| (16) Porcupine Beater | (17) Two-Part Grid | (18) Air Inlet |

In the above figure the feed to the RN cleaner is given directly from the step cleaner (zone 2) onto a feed lattice. The pressure roller and the pair of feed roller help to give a steady and predetermined feed of the fibres to the beater. The surface of the beater is covered with metal blades and has double hardened working edges. Beneath the beater two grid bars are placed that covers half of the circumference of the beater. These grids are fully adjustable.

Another very fine example of fine opener and cleaner is a Rando Cleaner as shown below:

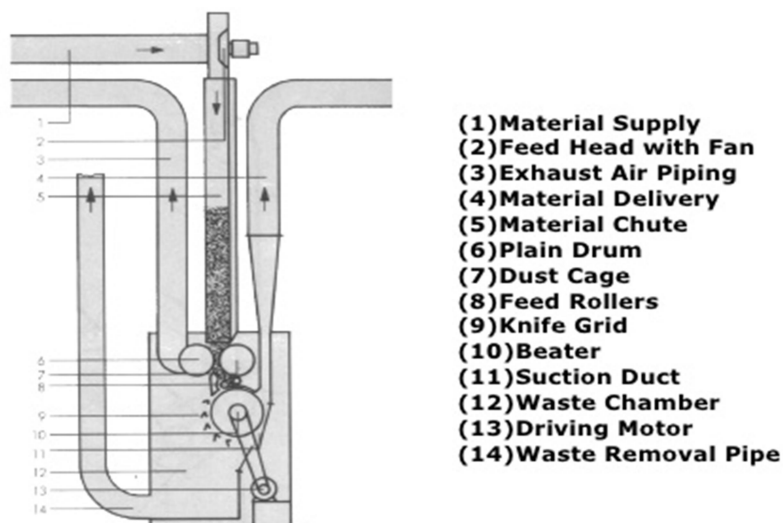


Rando Cleaner By Carolina Machine Co.

This opener and cleaner perform its working by using multiple rollers having their surfaces covered with saw teeth. All of these rollers move in opposite direction to one another and hence does the opening and cleaning by not only the beating action but also due to the opposing spikes principle.

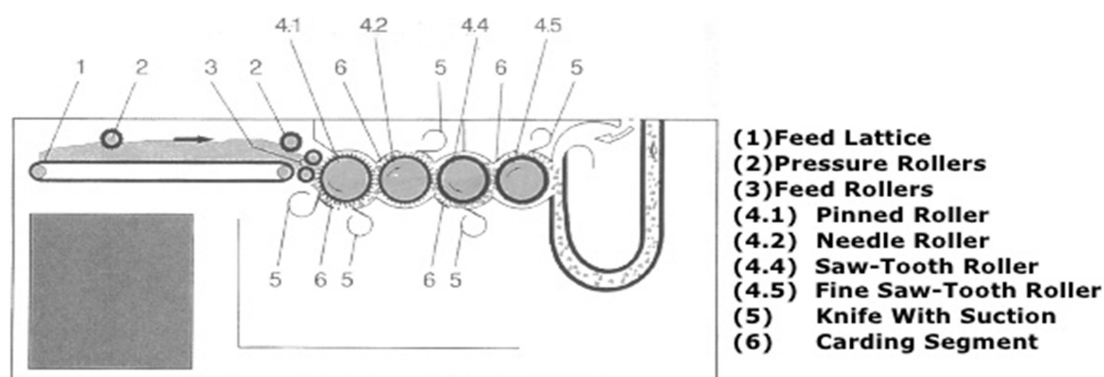
Zone-5 (Intense Opening & Cleaning Machines)

In majority of the cases the Zone 5 machines utilizes either the Kirschner beater or the carding roller (roller covered with saw teeth) as the main opening and cleaning device. However the way and the place where these opening rollers are used vary from manufacturer to manufacturer. A widely used intense opener and cleaner is the Rieter ERM cleaner as shown below:



Here again a fan is used that sucks the fibres processed from the previous machine of the blow room line into the filling chute or filling chamber of this machine. The mass of fibres is condensed with the help of drum roller and pair of feed rollers and is subjected to a drum beater whose surface is either covered with saw teeth or bladed discs. The beaters thoroughly opens the fibre material and transports it to the next stage by suction, while the trash removed during the beating and opening action passes through the grids blades and is collected in the waste chamber.

Another type of an intense opener and cleaner is shown below:



Truetzschler Cleanomat
Zone-6 (Card Feed Preparation Machine)

Card Feed Preparation Zone

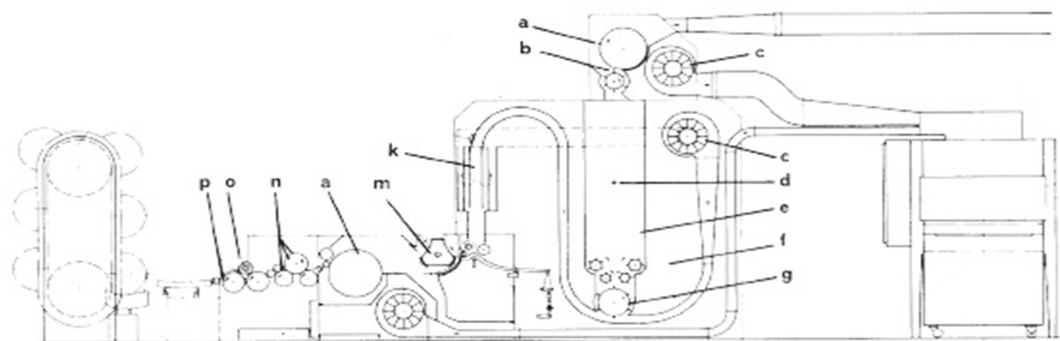
The feed to the carding machine is possible in two ways i.e. pneumatic chute feed with fibres in opened form and lap feed with fibres in form of a sheet or web. However whatever the feed method is used, it is essential that the feeding material to the card should be homogenous over a long term period. In this regard the lap feed is generally preferred because:

- (1) The lap feed to the card is less problematic and it is much easy to control the homogeneity of the lap as compared to chute feed.
- (2) It can be easily operated with several blends.

With these advantages the lap feed also has some serious disadvantages:

- (1) Greater manual effort is required to transport the lap roller.
- (2) Laps can be an additional source of faults.
- (3) When the lap roller becomes full it has to be replaced by a new empty one, it also requires extra effort.
- (4) Since laps are heavily compressed, it puts additional burden on the carding machine.

Because of these serious limitations all the modern cards are fed with chute feed rather than lap feed. However if lap feed is to be prepared, it is done on a machine called as a scutcher as shown below:



(a) Perforated Drum
(d) Photocell
(g) Opening Roller
(n) Calender Rollers

(b) Pocketed Roller
(e) Reserve Chute
(k) Feed Chute
(o) Lap Tube

(c) Fan
(f) Take-off Rollers
(m) Kirschner Beater
(p) Winding Roller

The main objectives or functions of a scutcher machine are:

- (1) Opening
- (2) Cleaning
- (3) Regulating

(4) Lap Formation

Typically a scutcher machine can be divided into the following regions:

- (1) Feeding Region
- (2) Opening & Cleaning Region
- (3) Lap Forming Region
- (4) Lap Doffing Region

(1) Feeding Region

With the help of air suction produced by a suction fan (c), the fibre material from the previous machine enters the scutcher machine and is drawn against a perforated drum (a). The drum revolves rapidly and removes the air from the fibres and hence does some dust removal. A pocketed roller (b) strips off the fibres from the perforated drum and throws it to the reserve chute (e). A photocell (d) is used in to maintain the amount of fibre present in the reserve chute. At the bottom of the reserve chute with the help of the two pairs of take-off rollers (f) and an opening roller (g), the fibre mass is thrown into a narrow feed chute (k). During the transport of the fibres in the feed chute high air pressure condenses the fibre mass into a form of a strand or a web. A pressure measuring and control system ensures a steady air pressure and air flow so that even strand of fibres may be obtained.

(2) Opening & Cleaning Region

The opening and cleaning region of the scutcher line is carried out by using a Kirschner beater. The feed to the beater is given in a very controlled manner by using a feed roller and set of pedal levers. 18 set of pedal levers form a feed plate. The levers press the fibres web with the feed roller with a uniform pressure that changes the thickness of the web. Any variation in the thickness of the fibres web will cause the lever to move up and down. This up and down movement of the lever is translated to alter the speed of the feed rollers so that a constant thickness of the web may be obtained.

The grid under the Kirschner beater is made up of number of triangular bars (most commonly 10) out which the first few can be adjusted independently while the others are adjusted in groups.

(3) Lap Forming Region

The lap formation takes place with the use of a perforated drum (a) that removes the air currents by sucking them into its perforations. As the perforated drum rotates, a single layer of a compact lap is formed on the surface of the drum.

The layer of lap produced on the drum is removed with the help of special stripping rollers and is then subjected to set of three calendering roller with one large calender roller placed on top of the other two calender rollers. The calendering rollers exert a constant equally distributed pressure up to 6000 kg. Because of this high pressure the lap is uniformly condensed and its thickness is reduced. The compressed lap is then wound on a lap tube (o) with the help of two winding rollers (p). The winding rollers also exert a pressure of about 1000

kg so that a condensed lap roll may be produced having a diameter up to 55 cm and it weighs up to 40 kg.

The scutcher machines are also fitted with lap weighing devices that monitor the weight of the lap roll. Any variation in the weight of the lap from a preset value is registered and based on the variation a signal is given to the servo motor that controls the speed of the machine. If the weight of the lap roll increases the speed of the machine is increased and vice versa.

(4) Lap Doffing Region

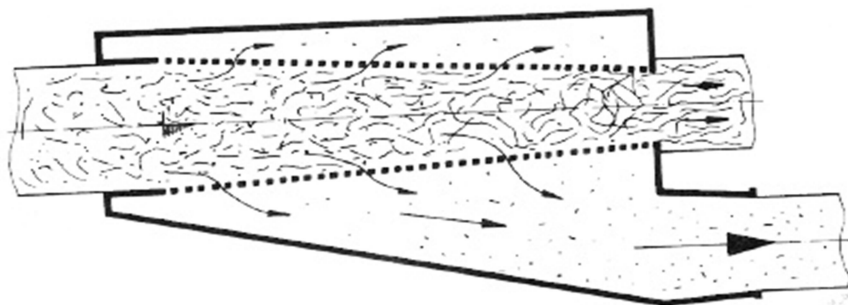
When a lap of required diameter and weight is formed then that completed lap roll must be replaced by a new empty one. This replacement of a full lap roll by an empty one is called as doffing. Doffing can either be carried out manually by workers or in modern machines it is done by automatic doffing units.

Dust Removal at Blow Room

Dust and microdust are the finest particles of trash. Their removal takes place at various stages in the blow room. Two techniques are mostly used for the removal of dust:

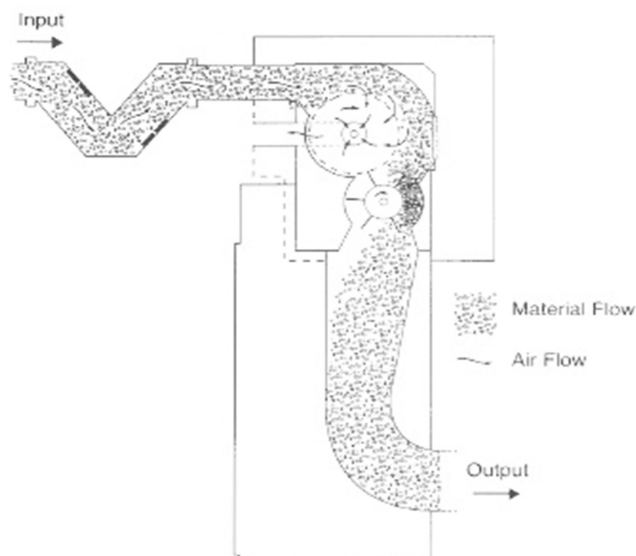
- (1) By separating the fibres and releasing dust into air, this dust is then removed by removing the dust contaminated air. The release of dust occurs whenever the fibres are rolled, beaten or opened up. In this type of arrangement its not only important to remove the dust contaminated air but also extremely important to maintain a dust free atmosphere in the blow room.
- (2) By separating the dust particles directly from the fibres through suction and scarping. This arrangement is better as compared to the first one as chances of dust to fly in the atmosphere are not present. Many different techniques are used to separate the dust from the fibres, most common ones are:
 - (i) Use of perforated drums.
 - (ii) Use of Stationary Perforated Surfaces.
 - (iii) Circulating perforated belts.
 - (iv) Stationary combs

The perforated drums and perforated surfaces are the most commonly used techniques for dust removal. For example, in the following diagram a Rieter dust extractor is shown that make use of stationary perforated surfaces.



The equipment includes a specially designed converging pneumatic duct having perforations on its either side. This duct is enclosed in a chamber. As the material passes through the duct a strong suction fan draws off the fine dust particles from the fibres.

In the following figure Truetzschler dust extractor is shown that make use of rotary perforated drum:



Here the incoming material is drawn on a perforated drum with the help of air stream. This air stream is then removed by using a high vacuum exhaust through the drum perforation using a suction fan. By doing so, fine dust also gets removed along with the air. The fibre material is stripped off the perforated drum with the help of a paddle roller. The stripped fibre material is then transported to next stage with the help of a suction provided at that end.

Cleaning Efficiency of Blow Room

The effectiveness of a machine or series of machines in a blow room to remove the trash in the fibres is expressed as its cleaning efficiency and is given by:

$$\% \text{Cleaning Efficiency} = \frac{\% \text{ trash in raw fibres} - \% \text{ trash in processed fibres}}{\% \text{ trash in raw fibres}} \times 100$$

Another very practical equation to find the cleaning efficiency is:

$$\% \text{Cleaning Efficiency} = \frac{\% \text{ Waste Removed} \times \% \text{ Trash in Waste}}{\% \text{Trash in Raw Fibres}} \times 100$$

How Much Waste To Remove

All openers & cleaners along with foreign matter also remove a certain amount of short fibres (also called as lint). The composite of trash, dust, fibre fragments and fibres removed is called as waste. Depending upon the machine design and intensity of opening and cleaning used, the removed waste has 40% to 70% of fibres by weight in it. So more fibres present in a waste makes the process more costly. To estimate the amount of waste that must be removed in the blow room in order to achieve a prescribed level of cleaning, following equation can be used:

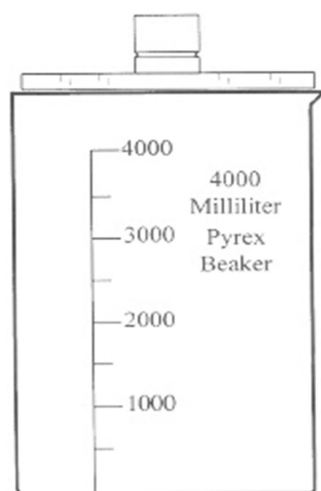
$$\% \text{ Waste Needed} = \frac{\% \text{ Trash in Bales} \times \% \text{ Trash to Remove}}{\% \text{ Trash in Waste}} \times 100$$

The amount of waste removed at each stage of cotton cleaning stage should be known for evaluation and can be found out as:

$$\% \text{ age Waste Removal} = \frac{\text{Waste Removed (Kg)}}{\text{Total Fibres Processed (Kg)}} \times 100$$

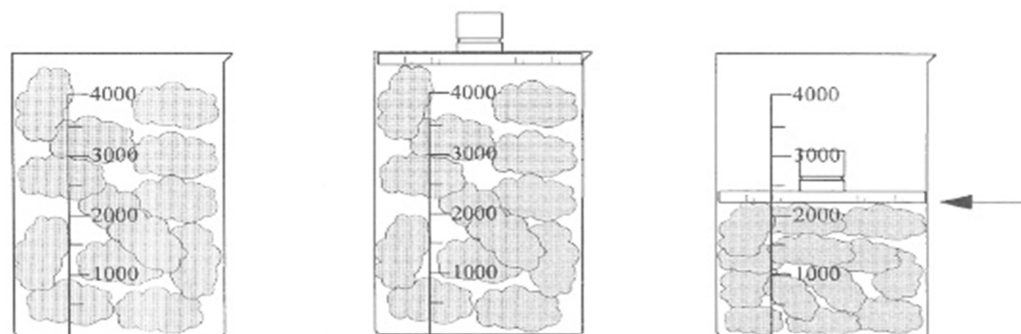
Openness Measurement

The opening effectiveness of a machine or series of machines in a blow room line can be found out by finding the openness index. The openness index can be found out by using a simple apparatus developed by the Textile Institute. The apparatus include a 4000 mm Pyrex beaker with inner diameter of 152 mm and a glass disc of 200 grams in weight. The glass disc has holes on its surface so that air can escape and its diameter is slightly less than the inner diameter of the beaker. The apparatus is shown below:



In order to find the openness index, the following procedure is followed:

- (1) A random sample from processing point is taken with a care that openness of the fibre is not disturbed.
- (2) The Pyrex beaker is uniformly filled with the fibre sample.
- (3) The 200 grams disc is placed on top of the fibre with a care that disc should not settle at a sharp angle.
- (4) The volume of the compressed sample is noted down.



- (5) The disc is removed and sample weight is found out
- (6) The openness index is then calculated as:

$$\text{Openness Index} = \frac{\text{Volume of Fibres (ml)}}{\text{Weight of Fibres (gms)}} \times \text{Specific Gravity of Fibre}$$

In case of blended fibres, the blended specific gravity is taken as:

$$\text{Blended Specific Gravity} = (\text{Specific Gravity of Component1} \times \% \text{age in Blend}) + (\text{Specific Gravity of Component2} \times \% \text{age in Blend})$$

(7) In order to have accurate results 8 to 10 readings are taken.

The following table shows the change in openness index of fibres after being processed by various machines and components in the blow room line.

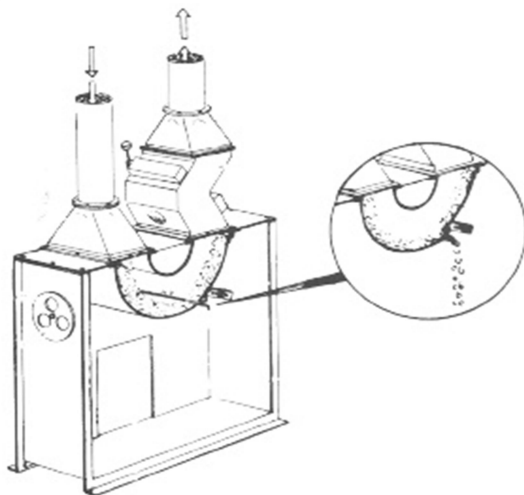
Machine	Change in Openness Index
Hopper Feeder	40 to 50
Top Feeder	80 to 85
Coarse Opener & Cleaner	5 to 10
Fine Opener & Cleaner	15 to 25
Intense Opener & Cleaner	20 to 30
Mixer & Blender	0
Transport Fan	0

Blow Room Accessories

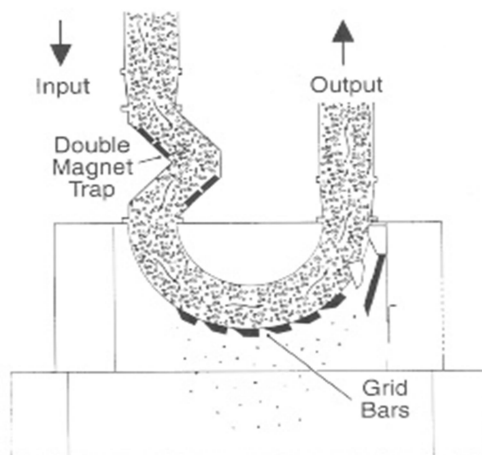
In addition to the main machinery of the blow room many useful accessories are also used such as:

- (1) Heavy Particle Separator (HPS)
- (2) Magnetic Metal Traps.
- (3) Fire Eliminator
- (4) Waste Disposal

The heavy particle separator (HPS) removes heavy particle like metal, plastic, wood, etc. These units take advantage of greater inertia of heavier particles in order to remove them. For example in the following figure a heavy particle separator is shown:



Similarly magnetic traps are also but will naturally remove only metallic particles. These magnetic traps can either be used individually or in combination with the heavy particle separator (HPS). One such example is shown below:



If these heavy particles are not removed before processing of fibres then at high speed beaters, they may generate spark resulting in fire. Since the fibres are flammable they can cause lot of damage to the machinery and raw fibre and sometimes can also become life threatening.

So in order to have extra protection in the blow room machinery, it is sometimes also equipped with fire eliminators. The fire eliminator on detecting a spark or a burning material immediately transports the fibre material to stand in open air. Simultaneously an alarm is given and the blow room line is switched off.

THE CARDING PROCESS

The carding is a one of the most important process of the short staple spinning system. Carding is an operation where the tufty condition of the fibres is converted into an individual fibre form. The separation of fibres in individual form is one fundamental operation of carding while the other fundamental operation is the formation of the card sliver. The carding is a very important process because unless the fibres are separated into individuals, they can not be spun into smooth and uniform yarns neither can they be blended properly with other fibres.

Functions of Carding

- (1) **Opening:** As the blow room only opens the fibre mass from larger tufts to small ones, the main objective of the carding machine is to further open up the smallest tufts into an individual fibre form.
- (2) **Cleaning:** The removal of impurities is also an important objective carried out by the card. Since not all the impurities are removed by the blow room, it is essential at the carding to remove the remaining impurities. Modern carding machines can remove about 85 to 95% of the foreign matter present in the fed fibres. The overall degree of cleaning achieved by both blow room and carding room can be as high as 95 to 99%.
- (3) **Mixing & Blending:** As the fibres are processed in the carding machine, they are not only opened up to the extent of the individual fibre form but also are thoroughly mixed together.

Sometimes blending of two or more different types of fibres can take place at the carding machine. The card can be a very good point of blending as with the carding action an intimate fibre to fibre blending is achieved.

- (4) **Disentanglement of Neps:** Because of the repetitive beating and opening of the fibres, the number of neps increases from machine to machine in the blow room line. The carding machine due to its special action on the fibres opens the majority of the neps and hence their number is reduced considerably.
- (5) **Removal of short fibres:** The carding machine also removes a very small quantity of short fibres. The amount of short fibres removed at the carding process is not more than 1%.
- (6) **Sliver Formation:** The end product of the carding machine is produced in a form of a cylindrical mass of fibres called as silver. The sliver is the very first intermediate product of spinning that start to resemble somehow like a yarn.
- (7) **Fibre Orientation:** Although not majority of the fibres in the card sliver are parallel and aligned however with formation of the card sliver, the fibres for the very first time becomes slightly parallel and assumes some longitudinal orientation. So the carding process also helps to create partial longitudinal orientation of the fibres.

Types of Carding Machines

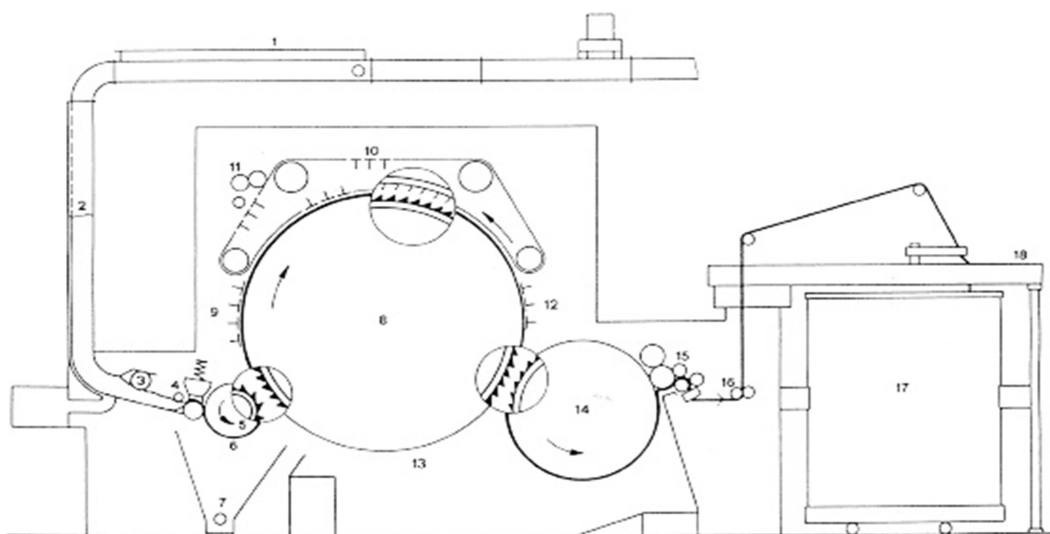
Depending upon the staple length of the fibres to be processed, two types of carding machines are available:

- (1) Revolving Flat Card
- (2) Roller and Clearer Card

Revolving flat card is meant for short staple fibres with staple length up to 2 inches. The name 'Revolving Flat' card is given because these cards make use of flats that revolve on an endless path. The cotton fibres are carded using the revolving flat card.

The roller and clearer card instead of having revolving flats have number of pairs of working and clearing rollers based on which its name is given. The roller and clearer card is mainly used for woollen fibres and is also sometimes called as woollen card.

Flat Revolving Card and its Components



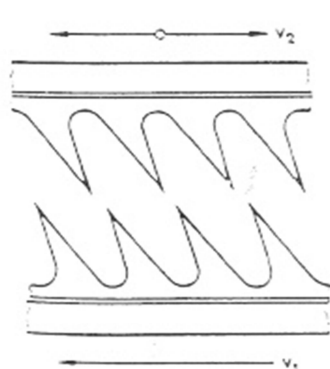
Description of Parts

- | | | |
|-----------------------|--------------------|---------------------------|
| (1) Conveying Duct | (2) Feed Chute | (3) Feed Roller |
| (4) Card Feed | (5) Taker-in | (6) Knife Grid |
| (7) Suction Duct | (8) Cylinder | (9) Front Carding Segment |
| (10) Flats | (11) Cleaning unit | (12) Post Carding Segment |
| (13) Cylinder Grid | (14) Doffer | (15) Stripping Device |
| (16) Calender Rollers | (17) Can | (18) Coiler |

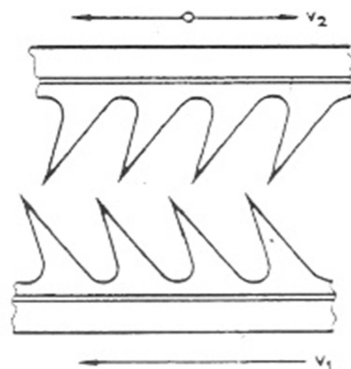
Principles of Working

The carding action refers to passing of fibre material in between two moving wire surfaces. This typical action is repeatedly carried out in the carding machine to individualize the fibres. At various stages of the carding machine the fibres are forced to pass through closely spaced surfaces covered with sharp metal teeth. The use of these sharp pointed surfaces give rise to two types of actions:

- (1) Point to point action or Carding Action
- (2) Point to back action or Stripping Action



Carding Action



Stripping Action

(1) Carding Action

The carding action is used to separate and individualize fibres. This action takes place between:

- (i) Feed roller and taker-in
- (ii) Cylinder and flats

Requirements of Carding Action

- (a) There should be two moving wiry surfaces between which fibres are subjected.
- (b) The action between these two wiry surfaces should be point to point.
- (c) There should be a difference in the surface speed of these two surfaces. Greater the speed difference more carding power is achieved

$$\text{Carding Power} = \text{Surface Speed of Cylinder} / \text{Surface Speed of Flats}$$

To achieve best carding power, the speed of the flats should be kept as low as possible. The optimum running speed of flats is about 4 to 6 inches per minute. To vary the carding power the surface speed of the flats is altered depending upon the opening and cleaning required at carding.

- (d) The distance between the two wiry surfaces should be constant. For cotton fibres a gauge of 8/1000 to 10/1000 of an inch is used.

(2) Stripping Action

The stripping action is used to transfer the material from one place to the other. As the material is transferred by this action, opening and cleaning also takes place. Stripping action takes place between:

- (i) Taker-in and cylinder
- (ii) Cylinder and doffer
- (iii) Doffer and stripping roller

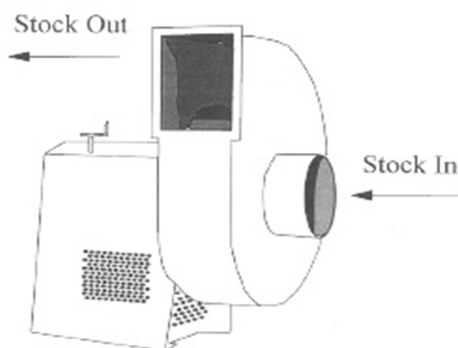
Requirements of Stripping Action

- (a) There should be two moving wiry surfaces.
- (b) The action between these two wiry surfaces must be point to back.
- (c) There should be a difference in the surface speed of two surfaces. However the difference in the surface speeds should not be as high as that in carding action. The recommended difference ratio is 1:2 i.e. the surface to which the material is to be transferred should have twice the surface speed.
- (d) The distance between the two wiry surfaces should be constant. For cotton fibres a gauge of 3/1000 to 7/1000 of an inch is used.

Material Feed To The Card

The fibre feed to the card coming from the blow room can either be in the form of a lap or in chute feed form. Although the lap may have some advantages but because of the serious limitations associated with the lap feed, it is no longer used in the modern short staple spinning, instead the chute feed is preferred.

The final machine in the modern blow room line also acts as a card feeder. Depending upon the amount of trash present in the raw fibres and the degree of opening and cleaning, the card feeder can either be a fine opener & cleaner or an intense opener and cleaner. Whatever the case may be, after the fibres are processed by the final machine, the fibres are transported with the help of a stock transport fan to the ducts and chutes that lead to the carding machine. A typical stock transport fan is shown below:

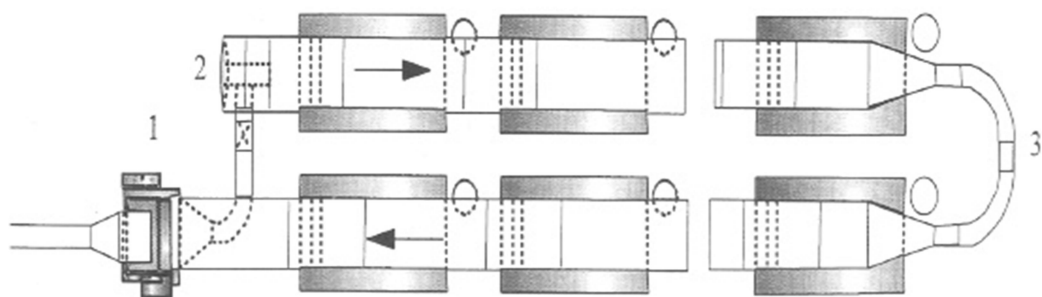


Generally one fine or intense opener and cleaner with a transport fan can give feed to line of 6 to 10 cards.

Transport Duct Systems

Two basic transport duct systems are used commercially:

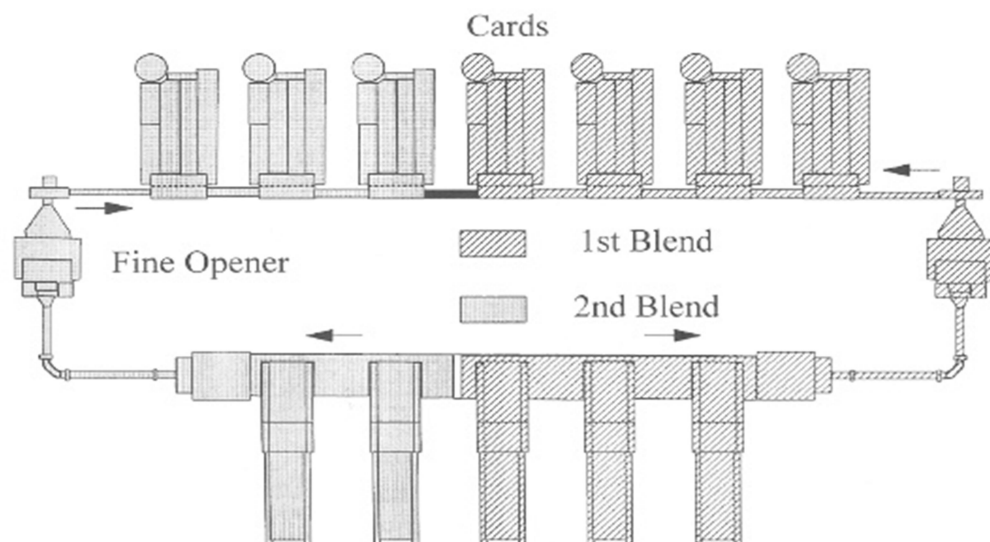
- (1) Re-Circulation System
- (2) Dead End System
- (1) Re-Circulation System



As shown above, in this system a fine or intense opener (1) with the help of a stock transport fan (2) supplies the opened fibres in the direction of arrows to a circular pneumatic duct. A number of carding machines are connected to this circular pneumatic duct with the help of vertical chutes. In this system an excess of fibre is supplied to the duct and the stock of fibres that do not fall in the vertical card chutes is returned back to the opener to be re-circulated.

(2) Dead-End System

A typical dead-end transport duct system is shown below:



As shown above, the system makes use of two separate fine openers each with a separate stock transport fan. Both of these openers feed the chute distribution duct from opposite sides. Since there is no re-circulation of fibres, the distribution duct can be blocked between any two particular cards thus allowing two groups of cards to process simultaneously two different fibre stocks independently. Blockage of the duct is achieved by used a simple slide plate having pressure sensitive sensors. These sensors control the speed of the feed roller of the opener.

The dead-end system is widely used in modern installments because of the following reasons:

- (iii) Fewer neps are generated.
- (iv) Fibre breakage is less.
- (v) The dead-end system has greater flexibility.
- (vi) Machinery instalment is easier.
- (vii) Feeding is easy and reliable.

Operation of Revolving Card

The operation of the card can be divided into three main areas:

- (1) Feeding
- (2) Carding
- (3) Doffing

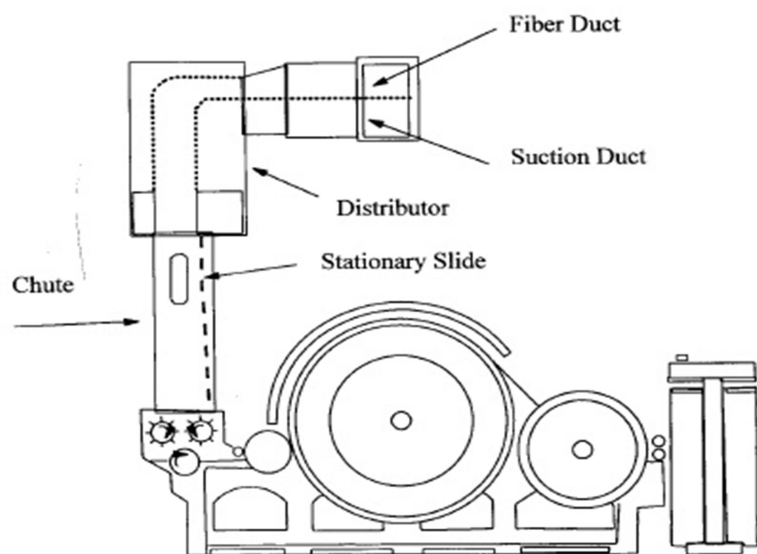
(1) Feeding Region

Functions of the Feeding Region

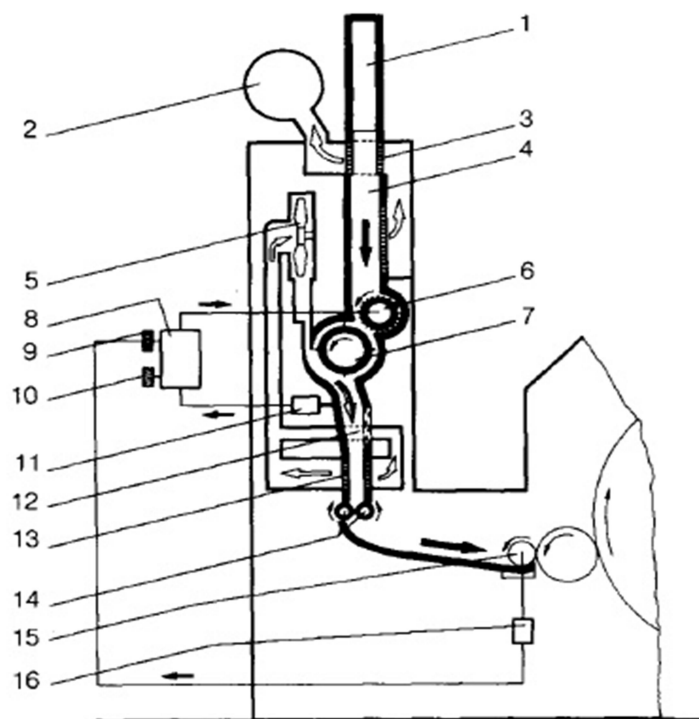
- (i) Feeding of fibres to the carding machine at a controlled and pre-determined rate according to the speed and productivity of the card.
- (ii) Thorough opening of the fibres.
- (iii) Removal of impurities (cleaning).
- (iv) Transferring the fibres from the taker-in to the main cylinder.

The Chute Feed System

The output of the carding machine i.e. card sliver should be regular and free from faults so that the resultant yarn made out of it can also be regular and consistent in quality. This is only possible if feed given to card is even and uniform. If the card uses lap feed then even feeding may not be a problem since the lap is already checked for its count accuracy at the scutcher. However the chute feed is more sensitive and inconsistent. To obtain even chute feeding, the fibres in the chute should be equally thick, evenly distributed over the whole width of the card and should have same density all over. In its simplest form the chute feed to the card is shown below:



This simple arrangement is called as a single chute system. Here the fibres are fed from the top. The fibres fall down due to gravity. A pair of delivery roller at the bottom discharge the fibre stock on to the card feed table. This is a conventional system used in old machinery and has poor consistency. A better and modern version of chute feeding system is the double chute system as shown below:

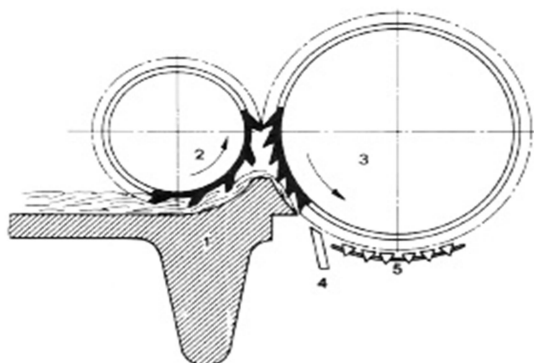


- | | | |
|-----------------------|-----------------------|-------------------------|
| (1) Distribution Duct | (2) Dust Extraction | (3) Air Outlet |
| (4) Reserve Trunk | (5) Fan | (6) Feed Roller |
| (7) Opening Roller | (8) Control Unit | (9) Pressure Adjustment |
| (10) Speed Adjustment | (11) Pressure Sensor | (12) Feed Trunk |
| (13) Air Outlet | (14) Take-off Rollers | (15) Card Feed Roller |
| (16) Speedometer | | |

This is a more sophisticated designed feeding system that makes use of a fan to keep consistent air pressure on the fibre stock. A sensor is used that register pressure variation on the fibres. If the pressure on the fibre mass increases, the speed of the feed roller is also increased and vice versa. This helps to keep a constant pressure on the fibres and hence a consistent fibrous stock is maintained in the lower compartment and a controlled feed is given to the carding machine.

Card Feeding Device

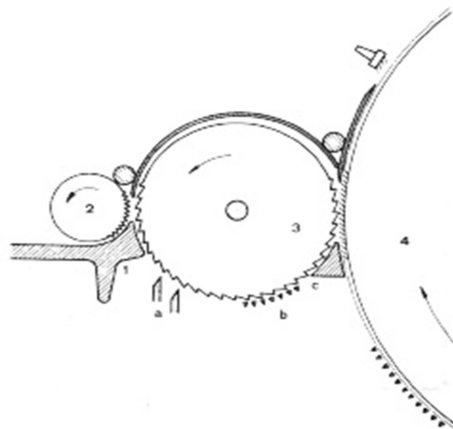
The fibre stock at a consistent rate is fed to the feed assembly of the card. In its simplest form, feed assembly is shown below:



This feed assembly comprises of a stationary feed table with a feed plate (1). A feed roller (2) with a diameter of 80 to 100 mm is used that presses the fibres against the feed plate. The surface of the feed roller is covered with saw tooth wire. The special design of the feed plate forces the fibre mass towards the taker-in and the carding begins.

Taker-in and its Operation

The taker-in roller has a diameter of about 250 mm having its surface covered with saw tooth. The speed of taker-in roller ranges between 800 to 1500 rpm. Beneath the taker-in an enclosure of grid elements for cleaning purpose are used.



Working at 1000 rpm the taker-in provides 600,000 beating points per second with a circumferential speed of about 50 km per hour and a draft of about 1000 is given. This severe point to point or carding action of the taker-in does majority of the fibre opening and about 50% opening of the entire carding machine is achieved here.

Cleaning

The extensive opening of fibres at the taker-in allows the removal of impurities with the help of cleaning aids placed beneath the taker-in. The cleaning aid in the conventional card includes 1-2 mote knives and a grid whose half of the

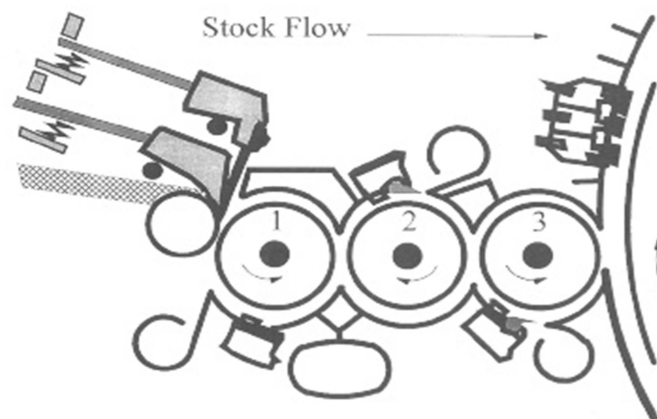
surface is perforated sheet and the other half is slotted sheet. The impurities are removed as the fibre mass at high speed strikes the knives and the grid. In modern cards to achieve high speeds instead of using grids triangular carding segments are used.

Transfer of Fibres to Main Cylinder

Between the surfaces of the taker-in and the main cylinder the condition of point to back action or stripping action arises. Due to the stripping action, the fibre material is transferred to the main cylinder. As the fibres are transferred to the main cylinder, longitudinal orientation of the fibres takes place here. This orientation depends upon the ratio of the surface speed taker-in to cylinder, ideally this ratio should be 1:2. i.e. a draft of slightly above 2 is given at this point.

Use of Multiple Taker-in Rollers

The standard carding machine has only one taker-in roller. At higher production rates to achieve good opening without fibre damage some manufacturers have come up with a technique of using two or sometimes three taker-in rollers. For example Truetschler DK-803 card as shown below utilizes three taker-in rollers:



Three taker-in rollers are used so that at very high speeds, the opening of fibres may be done gradually. This is done by:

- (v) Rotating all three taker-in rollers in opposition directions to each other.
- (vi) Keeping the speed of the each succeeding taker-in roller higher than the previous one (each roller runs 25% faster than the last one).
- (vii) Using finer tooth covering on each of three succeeding taker-in rollers to ensure steady flow and opening of material at high speed.

(2) Carding Region

Functions of the Carding Region

- (1) Intensive opening of the fibres into individual fibre form.

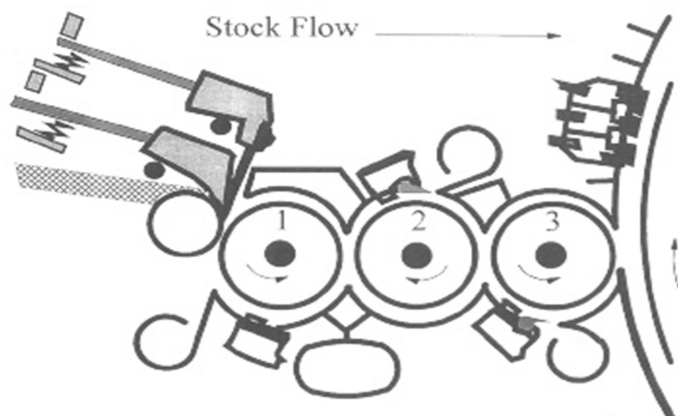
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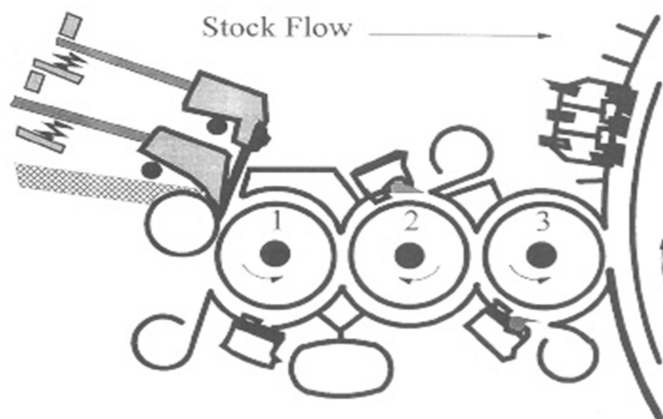
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(2) Carding Region

Functions of the Carding Region

- (1) Intensive opening of the fibres into individual fibre form.

- (2) Removal of the remaining trash and impurities.
- (3) Removal of short fibres

Carding Action

The major carding action takes place in the area between the main cylinder of the card and revolving flats. As the material is stripped off the taker-in towards the main cylinder, the fibre mass is subjected to severe carding action due to a significant difference in the surface speed of the cylinder and flats.

The flats move at a speed of about 4 to 6 inches per minute whereas the cylinder having a diameter of about 50 inches rotates at a speed of 150 to 600 rpm. The cylinder of this diameter and speed produces a surface speed which is about 10,000 times more than that of the flats. To alter the carding power, only the speed of flats is changed while the speed of the main cylinder remains the same. The direction of movement of flats in old cards is kept towards the front of the machine while in modern cards it is kept towards the back. The direction of motion of flats has no effect on the carding power of the machine.

For proper carding action, the space distance between the flats and main cylinder is very important. It should not be very great where carding action is compromised nor very less where fibre breakage may take place. For cotton fibres usually spacing of 10/1000" and for polyester 17/1000" is used.

Removal of Trash & Short Fibres

During the carding action between the flats and the main cylinder the waste gets embedded into the interspacing between the adjacent wires of the flats. The waste includes mainly the short fibres, neps, trash particles and dust. It is therefore very essential to clean off the surface of the flats so that the carding action between the main cylinder and the flats may not be affected. In old carding machines manual cleaning was carried out by stopping the machine after a specific period of time (4 to 6 hours). However in modern cards the waste removal off the flats is carried out continuously with the normal operation.

Carding Power

The degree of carding or carding power achieved on a carding machine can be expressed as:

$$\text{Carding Power} = \text{Rotary Speed of Cylinder} / \text{Surface Speed of Flats}$$

Since the carding power does not only depend upon this ratio, so instead the carding power of a card machine is more effectively expressed in terms number of beating points presented per fibre. This can easily be found out by averaging total number of fibres being fed in specific time divided by the total beating points presented in that same time.

$$\text{Carding Power} = \text{Beating Points per unit time} / \text{Fibres Fed in unit time}$$

For example in modern cards at the taker-in region there are about 0.3 beating points per fibre in other words approximately every three fibres will have one beating point. At the main carding region (between cylinder and flats) there are

about 10-15 beating points available for each fibre. So by comparing the number of points available per fibre, true carding power is determined.

The production rate of the modern carding machine has increased considerably. This means that more number of fibres will pass through the machine in any given time. In order to keep the same carding power, the number of beating points must also increase proportionately. This is possible by:

- (i) Having more points per unit area (finer clothing) on the carding surface.
- (ii) Increasing the speed of the carding rollers
- (iii) Using additional carding segments.

The clothing of the carding elements can not be changed to a great extent because a suitable distance must be given in between the two adjacent wires or points. For coarse fibres coarse clothing and for fine fibres fine clothing is used.

Similarly speeds of the carding rollers can not be increased infinitely. For example the production of the card has increased from 25 kg/hour to about 75 kg/hour. In order to achieve same carding power, old 300 rpm speed of the cylinder must be raised to 900 rpm. However this is not possible from both design and technological aspects and there would be lot of fibre damage at this speed.

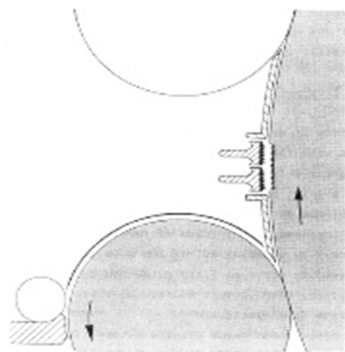
So the only approach that is applicable for increasing the carding power is the use of additional carding surfaces or carding positions. Two possibilities are present in this regard:

- (i) Increase in number of rollers used in carding machine.
- (ii) Use of additional carding segments.

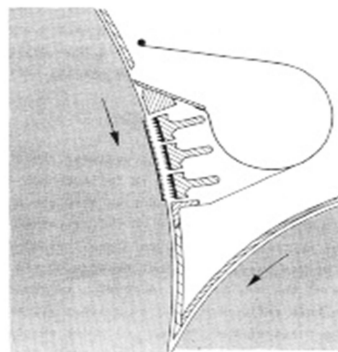
Use of Additional Carding Segments

Additional carding segments can be used in two positions in the carding machine:

- (1) Under the taker-in roller.
- (2) Between the taker-in and flats (pre-carding segment).
- (3) Between the flats and doffer (post-carding segment).



Pre-Carding Segment



Post-Carding Segment

- The carding segment used under the taker-in region is to facilitate better removal of impurities.

- The pre-carding segment helps in an efficient transfer of the fibres from the taker-in to the main cylinder. It also ensures that fibres are transferred evenly and no lumps of fibres are allowed to pass to the main cylinder.
- The post-carding segment is mostly used in conjunction with the mote knife. The short fibres, impurities and the dust passes through the small gap provided between the machine cover and the mote knife and are sucked off using a suction fan. This helps in removing further impurities during the operation in the card.

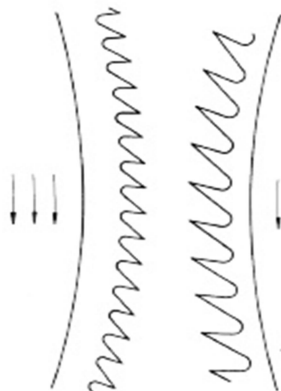
(3) Doffing Region

Functions of the Doffing Region

- (1) Transferring of fibres from the main cylinder on to the doffer.
- (2) Stripping the fibre web from the doffer.
- (3) Gathering the fibre web into a twistless strand (sliver).
- (4) Condensing or calendering the sliver.
- (5) Depositing the sliver into the sliver can.

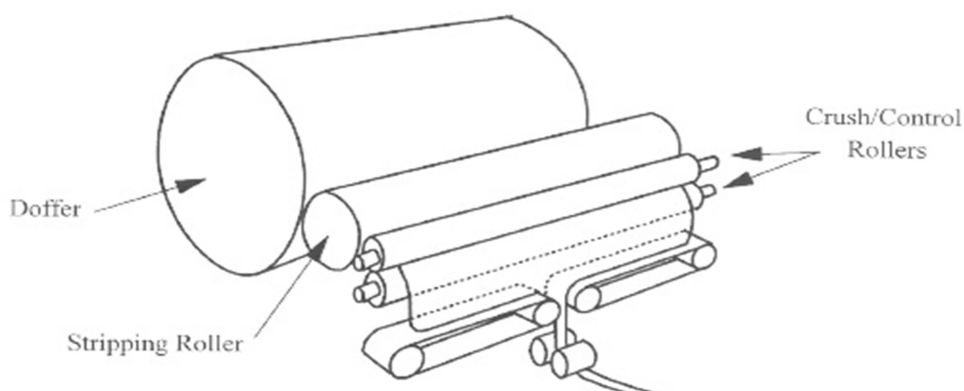
The Doffing Operation

The cylinder is followed by a roller called as doffer. The main purpose of the doffer is to take the individual fibres coming from the cylinder and to condense them to a web form. The diameter of the doffer is 24 to 27" and it rotates at a speed of 20 to 60 rpm. The surface speed of the cylinder is about 20 to 25 times more than the surface of the doffer. This helps to create a thick layer of fibres on the surface of the doffer. The action between the cylinder and doffer surfaces is shown below:



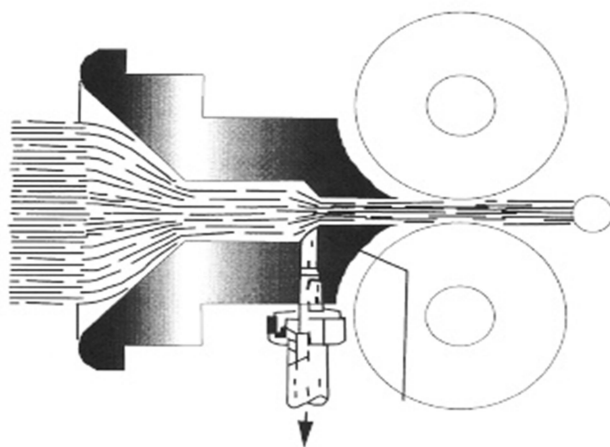
Owing to a very low surface speed of the doffer, the rate of transfer of the fibres is only about 0.2 to 0.3 i.e. on average a fibre rotates 3 to 5 times around the cylinder before it is transferred to the doffer. In order to improve the transfer rate, the spacing between the cylinder and doffer clothing is reduced to only 3/1000" as compared to a standard stripping gauge of 7/1000".

The Detaching Apparatus



In old conventional card the detaching of the web from the doffer is done by using an oscillating comb or doffer comb that moves up and down at a rate of 2500 strokes per minute. However in the modern high performance cards, the web of fibres from the doffer is detached by using a special detaching or stripping roller as shown in the figure above because the reciprocating motion of the doffer can not be used at higher speeds.

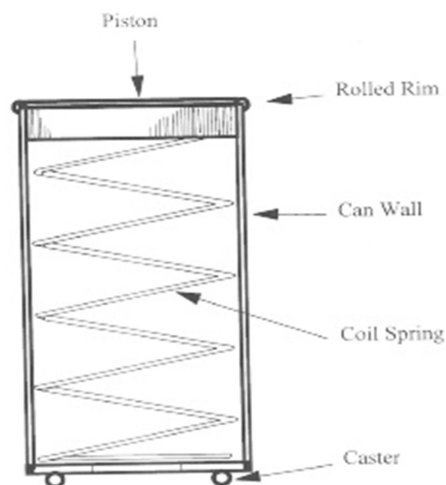
The detached web is then passed between a pair of calendar rollers or crush rollers placed on one another. The surface of these rollers is smooth and a pressure is applied in between these rollers. These rollers provide an additional point of cleaning because any foreign matter present in the fibres can be squashed and dropped off at this stage. The crushed fibre web is finally subjected to transverse belt sliver condenser. The opposite motions of these transverse belts convert the fibre web into a condensed strand of fibres commonly known as sliver. Another way of converting the fibre web into a sliver is by using a specially designed trumpet guide as shown below:



The special funnel shape of the trumpet guide forces the web stripped off the detaching roller to be condensed into a sliver form.

Depositing Sliver into Cans

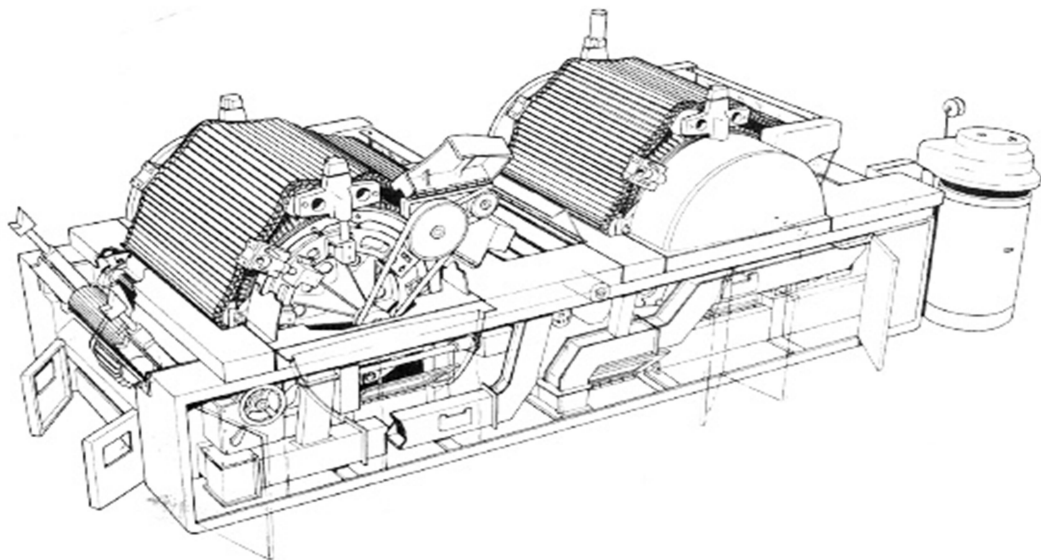
The sliver produced by the card must be properly stored in packages called as cans. Normally can used for sliver storage are 48 inches with a diameter of 30, 36 or 40 inches. The sliver coming from the transverse belt is passed through a special spiral motion of the coiler calendar rollers which helps to deposit the sliver in a spiral form.



Cross-sectional View of an empty Sliver Can

Duo or Tandem Carding

As the name implies the duo or tandem cards consist of two individual cards joined together as a single unit as shown below:



The doffer of the first card gives feed to the taker-in of the second card. The dual carding action on the fibres has a positive effect on the quality and blending of the fibres. Research has shown that tandem cards result in lower nep count, improved yarn appearance and also reduces yarn breakage during spinning. However the main disadvantages of the tandem carding are its very high initial cost, high power consumption and higher maintenance cost. Also since high performance cards can give almost the same quality of carding as that of tandem carding, the higher cost of tandem carding is not justified for its common use. Due to this reason tandem carding has not become very popular.

Draft

The degree of reduction in the linear density of the fibre material is called as the draft. Draft can be expressed in two forms:

- (1) Actual or Technical Draft

$$\textbf{Actual Draft} = \textbf{Linear Density of Input} / \textbf{Linear Density of output}$$

- (2) Mechanical Draft

$$\textbf{Mechanical Draft} = \textbf{Linear Speed of Output} / \textbf{Linear Speed of Input}$$

If the percentage waste removal during the carding machine is (W) then the actual and mechanical draft are related to each other as:

$$\textbf{Mechanical Draft} = \textbf{Actual Draft} (1 - W/100)$$

THE COMBING PROCESS

Combing is an optional process in the processing of short staple fibres necessary for the preparation of high quality combed yarn. The process of combing is carried out after carding and the combed sliver after passing through the draw frame follows the regular path of yarn formation.

The carded sliver still has some trash particles, neps and short fibres in it. In addition to it, the individual fibres in the card sliver are not well aligned longitudinally and majority of them have hooked surfaces. The basic purpose of combing is to remove short fibres and remaining impurities and to make the fibres well aligned and straight so that only long high quality long fibres are used for yarn making a yarn. The carding process brings out following positive influence on the yarn character:

- (i) More uniform yarns and stronger yarns can be made as compared to carded yarns.
- (ii) Owing to greater cleanliness and alignment of the fibres, the combed yarns are much smoother and have better lustre as compared to carded yarns.
- (iii) Combed yarns are less hairy and compact as compared to carded yarns.
- (iv) Combed yarns can be spun into much finer counts as compared to the carded yarns. Counts finer than 40 Nc are usually spun with combing where uniformity and quality is required. However to make stronger yarns, even coarse yarns are spun by combing.
- (v) The combed yarn requires less twist as compared to carded yarns. So high quality knitted fabrics are also made from combed cotton to have better appearance and handle.

The combing process therefore results in an improvement in the quality of the yarn and also enables the spinner to spin finer yarn counts. However the above mentioned quality improvements in the yarn are obtained at a cost of additional machinery, additional process, extra labour and extra floor space. This increases the cost of yarn production considerably.

Functions of Combing

- (1) To separate the long fibres from the short ones. The longer fibres are processed into a combed sliver whereas the shorter fibres are removed as a waste. Depending upon the quality of the yarn required predetermined quantity of short fibres are removed during the combing process.
- (2) To eliminate the remaining impurities and trash left by the carding process. The waste combination of trash, short fibres and neps is collectively also called a noil. The amount of noil removed during combing ranges from 5% to 25% depending upon the quality of the yarn.
- (3) Elimination of majority of the neps in the fibre material
- (4) To straighten and align the separated long fibres.

- (5) To create a combed sliver with maximum possible evenness.

Degree of Combing

The quality of the combed yarn and degree of yarn fineness achievable depends upon the type and quality of the raw material and degree of combing carried out during the combing process. Based upon the degree of combing, following different combing processes can be employed in the production of a combed yarn:

- (1) **Scratch Combing** is carried out to produce lower quality of coarser combed yarns. In scratch combing only as little as 5% noil is removed. This slightly improves the quality of the yarn as compared to carded yarns. Scratched combed yarns are produced by using medium quality and medium lengths of fibres.
- (2) **Half Combing** removes noil in the range of 7 to 10%. Such degree of combing is again used for medium lengths of fibres.
- (3) **Normal Combing** is carried out in majority of the cases where fine quality of long fibres is combed with noil removal in the range of 10% to 15%.
- (4) **Super Combing or Fine Combing** is used for making best possible fine yarns. Here up to 25% noil is removed by using best quality Egyptian cotton.
- (5) **Double Combing** was once used with the finest Egyptian cotton to produce extremely fine counts of yarns. In this double stage of combing, noil up to 25% is removed. However this method is rarely used nowadays.

Comber Lap Preparation

Since the main function of combing is to remove short fibres, if the carded slivers are directly fed to the combing machine, the waste extraction would be very high and also lot of fibre breakage will take place. This is due to the fact that fibre orientation in the card sliver is very poor and also the card sliver has majority of hooked surfaces. So it is desirable for the card sliver to be prepared into such a form which is suitable for the combing operation. For this reason a suitable lap with straight and parallel fibres is formed which is presented as a feeding material to the comber.

The majority fibres in the card sliver have trailing hooks (about 50%). It has been established with experience and experiments that better combing results are obtained when majority of fibres presented to the comber has leading rather than trailing hooks. This is because the leading hooked fibres can be straightened out better and they pass into the combed sliver whereas the trailing hooked fibres have less chances of straightening and more chances of being removed as a noil. In order to straighten and align the fibres and also to convert the trailing hooks into leading position, even number of machines must be used in the preparation of a comber lap and most commonly two machine processes are used. Straightening and orientation of fibres is achieved by using roller drafting method in both of the preparatory operations. The total draft of both the machines ranges from 8 to 12. Since the drafting tend to cause imperfections and unevenness in the material, operation of doubling is also carried out. The

doubling not only helps to improve the evenness of the material but also is necessary to form a sheet of material which is converted into a lap.

Methods of Comber Lap Preparation

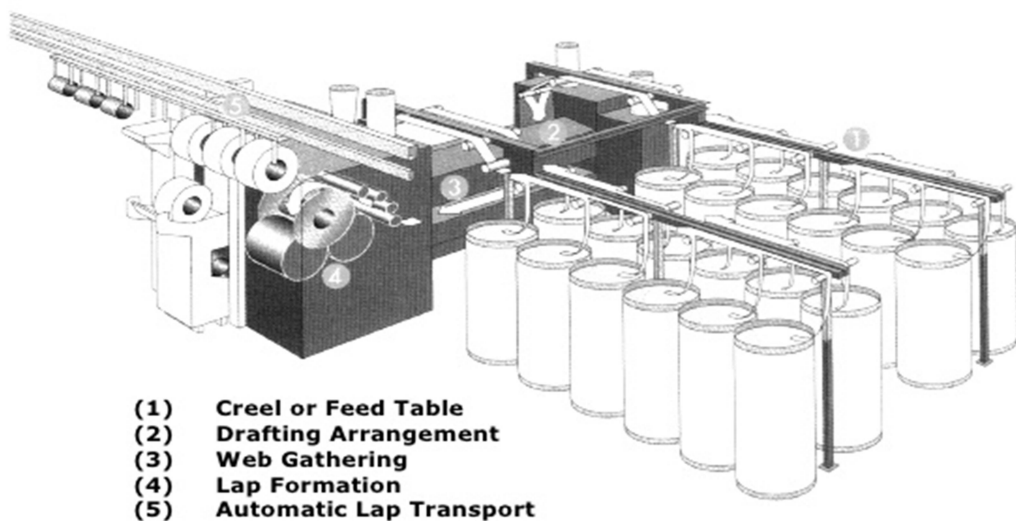
Commercially two systems of preparing the comber lap are used:

- (1) Lap Doubling System
- (2) Sliver Doubling System

(1) Lap Doubling System

In the lap doubling comber preparation system the carded sliver is passed through a sliver lap machine followed by a ribbon lap machine.

The Sliver Lap Machine



The sliver lap machine is divided into the following regions:

- (1) Creel Region
- (2) Drafting Region
- (3) Winding Region

(1) Creel Region

The creel of the machine consists of two feed arrangements; each usually holds 12 card sliver cans. All together it gives a doubling of 24. All card slivers after passing through series of guide rollers enter the drafting arrangement.

(2) Drafting Arrangement

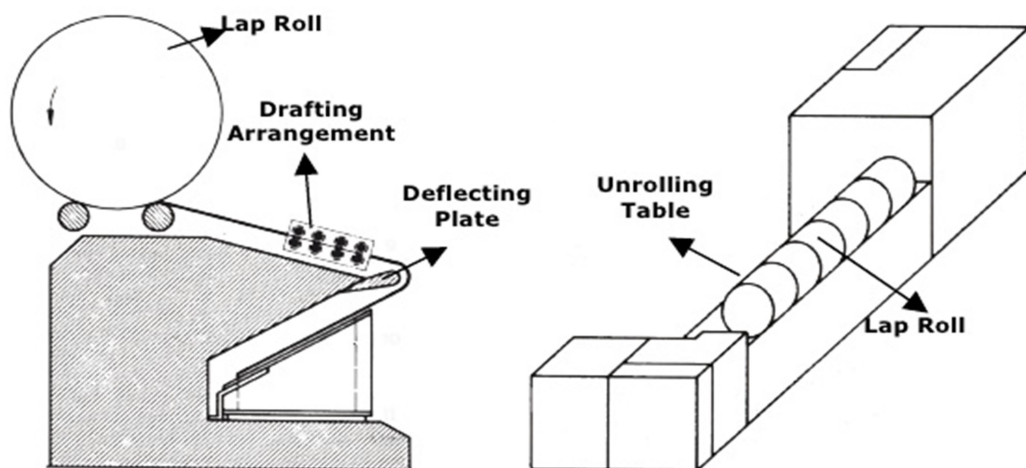
The sliver lap machine commonly uses a 4 over 4 roller drafting system with top roller pneumatically weighted. The pneumatic pressure can be adjusted up to 1600 Newtons. A total draft of 1.3 to 3 is given at this arrangement.

(3) Winding Region

The sheet or web of fibres after being drafted out is passed over a guide plate or deflecting plate which changes its direction towards four calender rollers. The high compression (up to 16000 Newtons) created by the calender rollers transforms the fibre web into a lap. The lap then passes through two winding rollers that press against the lap tube with a pressure of 10000 Newtons and assists in winding of the lap on to the lap tube. The lap tube is placed on lap weighing devices which on the modern machines automatically removes the lap roll when its required weight has been reached and is ejected on an automatic transport system that will take the lap roll directly to the next machine i.e. ribbon lap machine.

The Ribbon Lap Machine

The basic concept of ribbon lap machine is same as that of the of the sliver lap machine as shown below:



Here instead of a feed table a lap unrolling table is provided for 6 lap rolls. The sheet unrolled from the lap passes through a standard 4 over 4 roller drafting system where a draft of 3 to 6 can be given. The drafted material after passing through calender rollers is wound by the winding assembly on a lap tube. The ribbon lap machines have an advantage that it gives a doubling of 6 in web form and thus high degree of evenness in transverse direction is achieved.

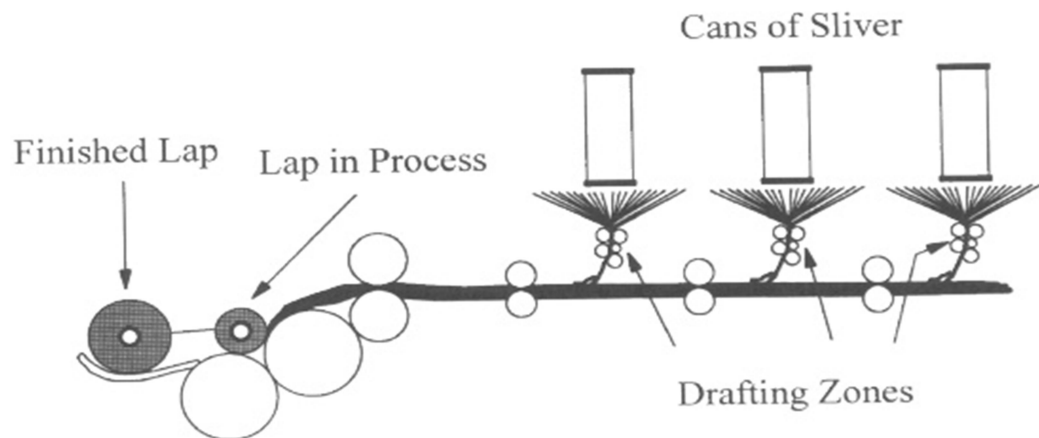
The lap doubling system is considered to be old conventional system of preparing comber lap. But with the introduction of high performance modern machinery the trend is tilting towards using a sliver doubling system rather than lap doubling.

(2) Sliver Doubling System

In the sliver doubling process the carded sliver is given first passage through a normal draw frame and then series of drawn slivers are given second passage through a sliver doubling machine.

Sliver Doubling Machine

The working principle of a modern sliver doubling machine also known as the super lap machine is shown below:



The super lap machine has three feeding heads in the creel portion with each head holding 16 to 20 draw sliver cans. All the slivers coming from each feeding head is passed through a vertically held 2 over 3 roller drafting system. The lap sheet formed by the combination of these drafted slivers are passed through a pair of calender rollers and is ultimately wound on the lap tube with the help of two working winding rollers.

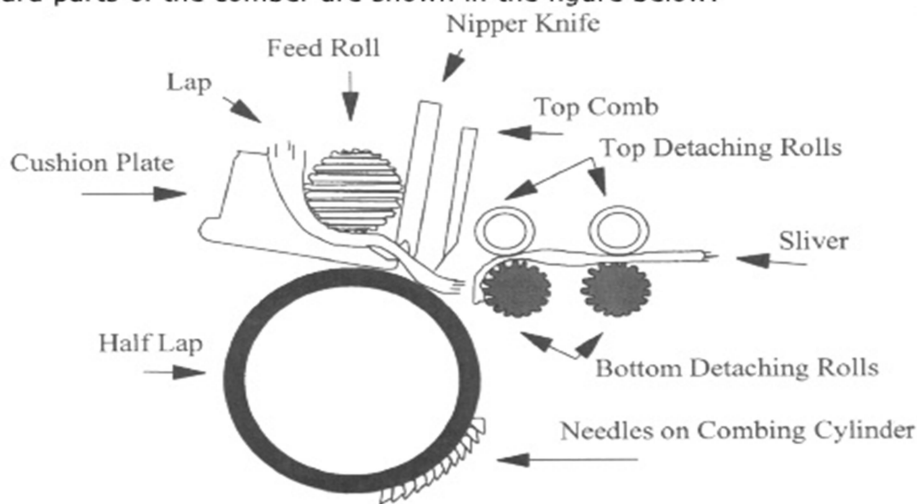
THE COMBING MACHINE

Many different types of combers are used for different fibre materials, combers can be classified into following types:

- (1) Rectilinear Combers (used for cotton)
- (2) Circular Combers (used for worsted)
- (3) Rotary Combers (used for spun silk)
- (4) Hackling Machines (used for bast fibres)

The rectilinear or cotton combers operate intermittently because the short length of the fibres does not allow continuous method of combing. One end of cotton fibre bundle is combed with cylinder comb or half lap having half of its circumference covered with teeth while the other end is combed with single row

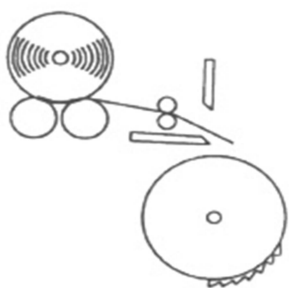
of needles called as the top comb. After both ends of the cotton fringe has been combed separately, the separated fringes are reunited by a piecing unit. The standard parts of the comb are shown in the figure below:



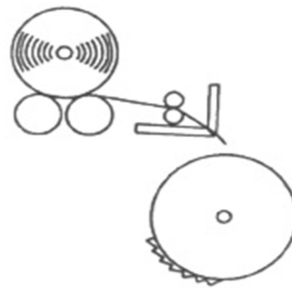
The combing of the cotton fibres is carried out in an intermittent cycle of operation called as the combing cycle. In one combing cycle, the short fibres are removed and the long fibres are passed forward into a sliver. One combing cycle can be divided into many phases

(1) Feeding

The combing cycle begins with the feed of the lap. The lap sheet is fed to the comb between the feed roller and smooth cushion plate also called as the bottom nipper. The top nipper or the nipper knife moves down to fix on the bottom nipper (cushion plate). Hence the lap sheet is gripped between the top and the bottom nippers.



Lap unrolls for feeding

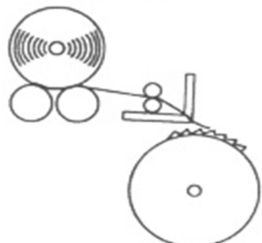


Top nipper moves down

(2) Cylinder or Half Lap Combing

As the lap is held by both the nippers, the half lap or the cylinder comb rotates and the protruding fringe of the fibres is combed with the help of needles mounted on the cylinder comb. Any fibres not held by the needles will be treated as short fibres and will be removed as a waste during the rotation of the circular

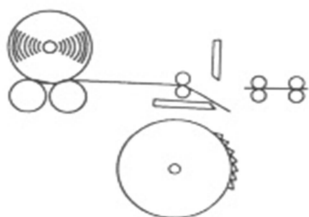
comb. The waste (noil) is removed from the surface of the needle with the help of a revolving brush mounted just below the cylinder. The waste removed is then collected by suction at the back of the comb.



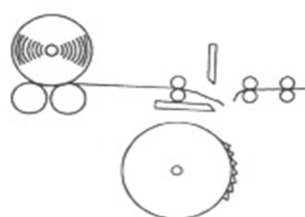
Half Lap Combing or Cylinder Combing

(3) Piecing

As the half lap or circular comb has finished combing and has cleared the fibre fringe, the detaching roller remains stationary and does not rotate however only the back top detaching roller rocks backward. At the same time the top nipper is raised while the cushion plate or bottom nipper rocks forward. Also the feed roller rotates by a small amount feeds a predetermined length of lap. This increases the length of the lap fringe and as the bottom nipper moves forward, the leading edge of the lap fringe is entered into the nip of the detaching rollers and initiates piecing. During piecing the top comb also starts descending.



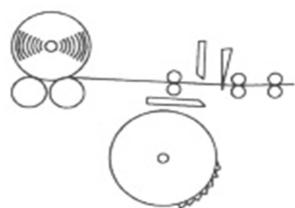
Retracting of Top Nipper



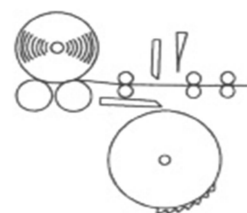
Detaching roller rocks backward

(4) Top Combing

Just as the piecing has started, a top comb with one row of needles is descended into the fibre fringe from the above. As the combed web of fibres is pieced or connected to the surface of the detaching rollers, the detaching rollers now start rotating forward and the combed web of fibres is pulled through the top comb. As the fibres web is pulled through the top comb, short fibres, neps and entanglements not removed by the circular comb is removed here by the top comb. As the bottom nipper reaches its maximum forward position, the detaching is completed because the detaching rollers continue to move forward while the bottom nipper begins to rock backwards. As detaching finishes the top comb is withdrawn upwards.

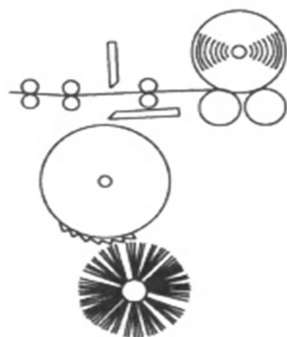


Top combing & Detaching



Retracting of Top Comb

The feed roller again rotates and advances a new short section of the lap to be combed by the bottom circular comb and the same combing cycle continues.

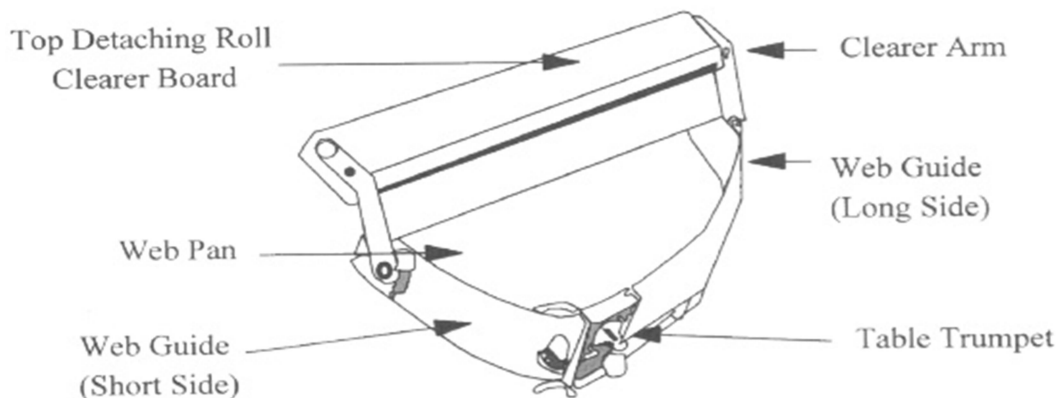


New Feeding

On a modern comber the cycle of combing takes place 3 to 5 times in a second.

(5) Sliver Condensing & Drafting

The combed web taken by the detaching rollers is delivered to the web pan having a trumpet guide on its one side as shown below:



The combed web is pulled through the trumpet guide with the help of a pair of calender rollers that converts the web into a combed sliver. The combed slivers coming from all the heads of the comber are laid side by side and are passed through a draw box where a draft of 5 to 12 is given. Most commonly a 3 over 5

roller drafting is used where the rollers are inclined at an angle of 60°. The drafted slivers are coiled into sliver cans. On modern combing machines, the sliver cans are automatically doffed on completion.

THE DRAWING PROCESS

The carding process is one of the most important process in short staple spinning as it separates fibres into individual form and also removes the remaining portion of impurities left by the blow room. Despite of many advantages of the carding process it has a big draw back of producing variation and misalignment of the fibres with in the card sliver. The alignment and the slight parallelization achieved at the carding region between the main cylinder and flat largely disappears again because of the doffing action at the doffer. During the transfer of the fibres from the cylinder to the doffer hooked surfaces in the fibres arise. About 50% of the fibres in the card sliver has trailing hooks, 15% fibres have leading hooks and 15% of the fibres have double hooks and only a small portion (20%) of the fibres remain straight.

In order to produce a strong and uniform yarn it is necessary to straighten and align the fibres and to improve the evenness of the sliver. All of these objectives are achieved by the drawing process carried out by a machine called as the draw frame. At the draw frame a number of card slivers are drawn or stretched between several pairs of rollers. As the fibres are attenuated or drafted, the fibres are straightened and aligned to the axis of the sliver in the direction in which they are drawn.

Functions of the Draw Frame

- (1) To straighten the fibres and to make them parallel to the central axis of the sliver. This is done by subjecting the sliver in between several pairs of rollers with each subsequent pair of rollers moving faster than the previous one. The drafting tends to reduce the linear density of the sliver.
- (2) To improve the evenness of the sliver. This is achieved by feeding more than one sliver at the draw frame and drawing it together. The feed of multiple slivers is called as doubling. Most commonly 6 to 8 sliver are fed to the draw frame and hence a doubling of 6 to 8 is achieved. The doubling reduces the mass variation of the sliver by averaging out the heavy and light sections of the sliver. The decrease in the linear density of the sliver caused by drafting is balanced out proportionately by combining a number of card slivers.
- (3) The doubling process at the draw frame in addition to improve the evenness of the silver can also be used to blend different origin of fibres. For example to obtain a 50:50 blend of cotton and polyester fibres equal number of both cotton and polyester card slivers must be doubled together provided that the count of all card slivers is same.
- (4) To produce a proper weight of sliver required for the following process. Doubling and drafting are the two main processes employed at the draw

frame. Drafting tends to decrease the linear density of the sliver whereas doubling tends to cancel out the effect of drafting. If drafting and double are of same proportion then the drawn sliver will have same linear density as that of the card sliver. But if the drafting employed is more than the doubling then the resultant drawn sliver will be finer than the fed card sliver and vice versa. Therefore the degree of drafting and doubling actually depends upon the required final count of the yarn.

Main Parts of the Draw Frame

The draw frames are built with one or two deliveries. The single delivery draw frame is more efficient and flexible but the double delivery draw frames have the advantage of having twice the production covering nearly the same floor area as that of the single delivery draw frame. The double delivery draw frames also have a less initial cost. A standard draw frame is divided into following sections:

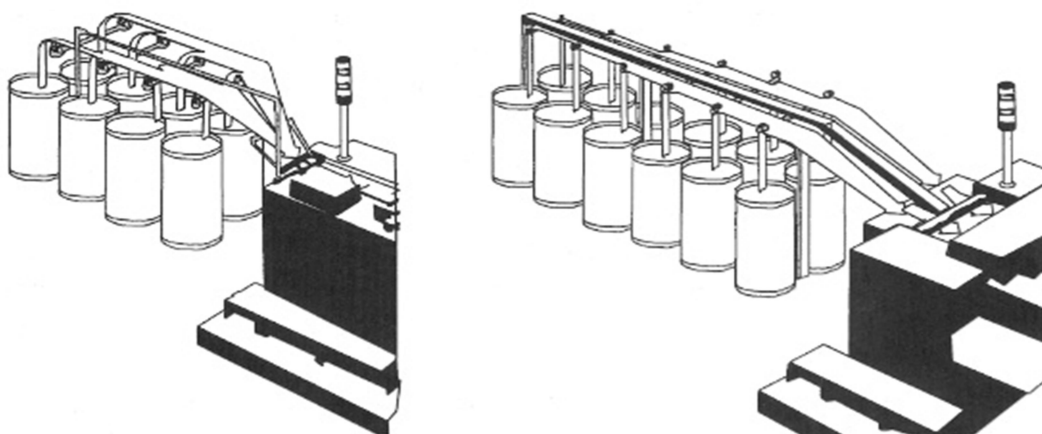
- (1) Creel Section
- (2) Drafting Section
- (3) Sliver Condensing Section
- (4) Coiler Section
- (5) Suction Section

(1) Creel Section

Creel is the portion of the draw frame where the card sliver cans are placed. The cans behind the draw frame are placed in two most common arrangements:

- (i) The nested creel arrangement
- (ii) In-Line creel arrangement

In nested creel arrangement, the cans are placed in a rectangular group. Such an arrangement is exclusively used for single delivery draw frames. On the other hand the in-line creel arrangement has all the cans placed in a straight line and is mostly used for double delivery draw frames. Both the arrangements are shown below:



Nested Arrangement

In-Line Arrangement

The sliver coming out of each can is passed over a guide plate and is fed to the main drafting rollers. The sliver is either directly pulled by the drafting rollers or in order to avoid unnecessary stretch it is pulled by power driven rollers placed just above the cans. The creel also sometimes has an automatic stop motion to detect sliver breaks and on breaking of any sliver, the machine will be stopped.

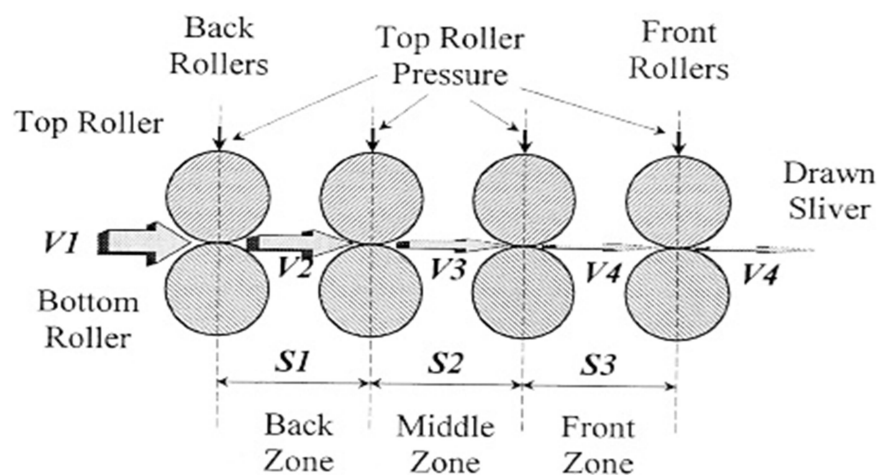
(2) Drafting Section

The drafting of the sliver at the draw frame is carried out by roller drafting method in which the card sliver is passed through two or more pairs of rollers. In modern draw frames the top roller used are rubber coated and are called as cots while the bottom rollers are steel rollers having fine flutes on their surfaces. The cots exert pressure on the bottom rollers and their surface is treated with anti-static material. The back cots exert less pressure as compared to the next succeeding cot in the drafting system.

The surface speed of each succeeding pair of roller is kept more than the previous one. The slower pair of roller grips the fibres whereas the next faster pair of rollers draws the fibres forward. This increases the length of the sliver and reduces its linear density by a factor equal to the ratio of the surface speed of the fast moving roller to the surface speed of the slow moving roller. This ratio is called as mechanical draft.

The distance between the two pair of rollers is called as drafting zone. The distance between the nip lines of the two adjacent pair of rollers is called the roller setting. The first pair of rollers (at the feed end) is called as the back rollers and the last pair of rollers (at the delivery end) is called as the front rollers.

The roller drafting systems used on various draw frames are of many types. However every roller drafting system is named according to the number of top and bottom rollers it has. Draw frames are available with 4 over 4, 3 over 3, 4 over 3, 5 over 3 and 3 over 4 roller arrangements. All of these arrangements give good results when set appropriately. A 4 over 4 roller drafting system is shown below:



The over 4 over 4 drafting system has four pair of rollers and hence has three drafting zones namely the back zone, middle zone and the front zone. The draft given in the back zone is called as the break draft, the draft in the middle zone is called as the middle draft and the draft given at the front zone is called as the main draft. The break draft is always smaller than middle draft and the main draft is always kept the greatest.

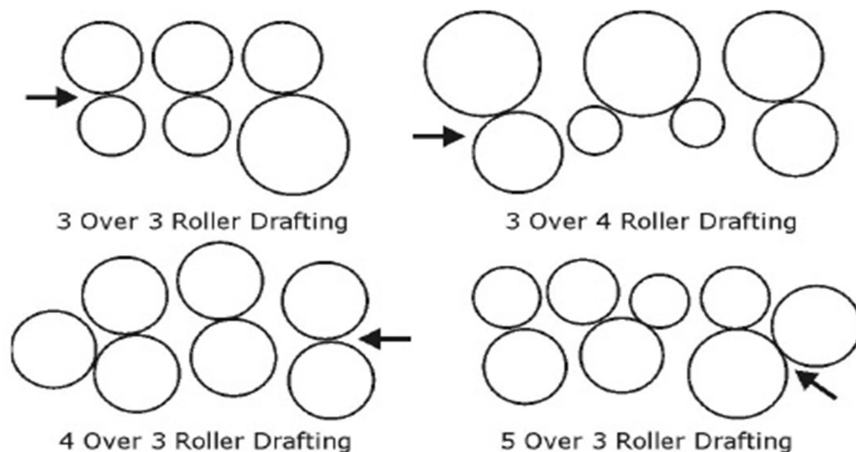
$$\text{Break Draft} = V_2 / V_1 \quad \text{Middle Draft} = V_3 / V_2 \quad \text{Main Draft} = V_4 / V_3$$

The total draft is the product of the individual drafts given in all drafting zones.

$$\text{Total Draft} = \text{Break Draft} \times \text{Middle Draft} \times \text{Main Draft}$$

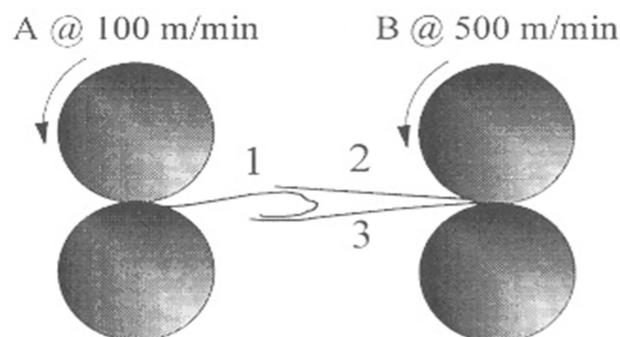
$$\text{Total Draft} = V_2 / V_1 \times V_3 / V_2 \times V_4 / V_3 = V_4 / V_1$$

In addition to 4 over 4 drafting system various other drafting systems are shown below:



Fibre Straightening During Drafting

As the fibres are drafted out at the draw frame, the hooked fibres are also straightened out. This is illustrated in below:



In this example for simplicity three fibres are shown to be caught between two pair of rollers. The roller pair (A) is moving at a linear speed of 100 m/min whereas the roller pair (B) is moving 5 times faster at 500 m/min. When the slower hooked fibre (1) held by the nip of roller pair (A) comes in contact with the faster moving fibres (1 & 2) held by the nip of roller pair (B), the faster fibres (1 & 2) will tend to pull the slower fibre (1) and the hooked end will be aligned with other fibres moving in the same direction.

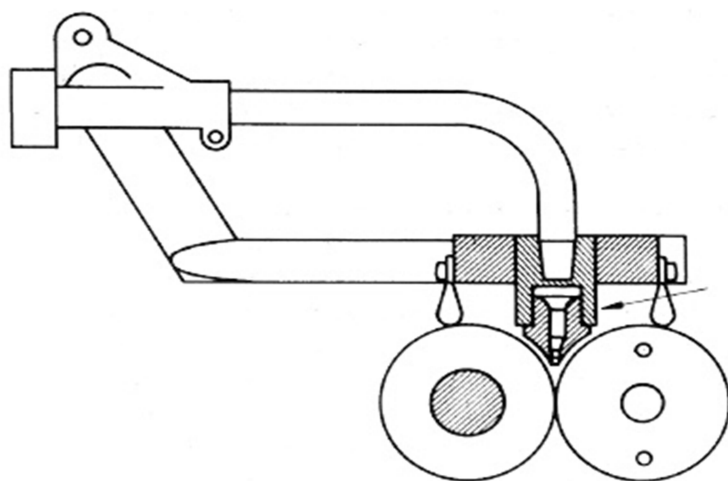
Roller Settings

The roller setting which is the distance between the nip lines of the two adjacent pair of rollers is mainly governed by the fibre length. The roller setting is kept widest apart in the back zone while it is narrowest in the front zone. This is due to the fact that fibres in the back zone will have more hooks and a wider spacing must be given in this zone to allow the fibres to attenuate and grow. Since fibres reaching the front zone will have many of their hooks removed by the previous zone so less wide roller spacing is required here.

When adjusting roller settings, the distance between the nips of the two adjacent rollers should be just wide enough to let the longest fibre grow. If the spacing is too narrow, the longer fibres will break. If the spacing is too wide then too many fibres will float in between the two draft zones. The floating fibres are the ones which are not held by any pair of drafting rollers. Floating fibres can bulge at a point to create thick and thin places. The succession of thick and thin places along the sliver is called as the drafting wave. Drafting wave may also be caused by worn off cots and other machine imperfections.

(3) Sliver Condensing Section

The flat fibre web (consisting of several card slivers) exiting the drafting section must be converted back into a web. The fibre web leaving the front pair of drafting rollers is passed through a converging tube and is guided to a specially designed condensing funnel called as the trumpet guide as shown below:

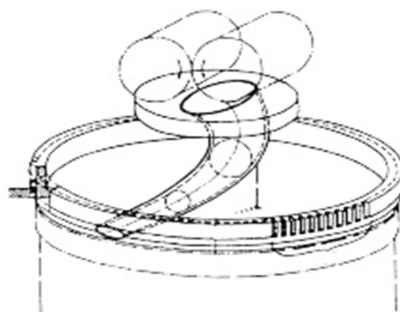


The degree of condensing at the trumpet guide is essential for providing a good fibre to fibre cohesion to hold them better in a sliver. However if too much condensing is done then the drawn sliver develops thick places.

After condensing of fibres at the trumpet guide back into a sliver form, the sliver is passed through a pair of calender rollers which does a further compressing of the fibre mass and ultimately deposits the drawn sliver into a sliver can.

(4) Coiler Section

The drawn sliver coming out of the calender rollers is passed through a coiler tube fixed on a coiler plate. The coiler gears fixed on the coiler plate help to rotate the coiler tube so that sliver can be laid in the can in form of special coils.



The can rests on the rotating plate, with the rotation of the plate the can also rotates. The rate of rotation of the can is kept slower than the rate of rotation of the coiler tube. This helps in proper deposition of drawn sliver in a spiral arrangement.

It is necessary to keep the sliver deposition rate slightly higher than the sliver delivery so that blockage of the sliver in the tube may be avoided. However this difference should not be too large where false draft may arise in the sliver.

5) suction

As the fibers move swiftly over the surface of the drafting rollers, dust and lint may be dislodged into the air. The purpose of the suction system of the draw frame is to remove these particles so that they might not get deposited on the surface of the drafting rollers and also to maintain a dust and lint free working environment. The accumulation of the fibrous mass on the surface of the rollers causes unevenness in drafting and sometimes also causes sliver breakages causing the machine to stop. A typical air suction used on the draw frame is as shown below:

