

Wollo university
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Department of Textile
Engineering

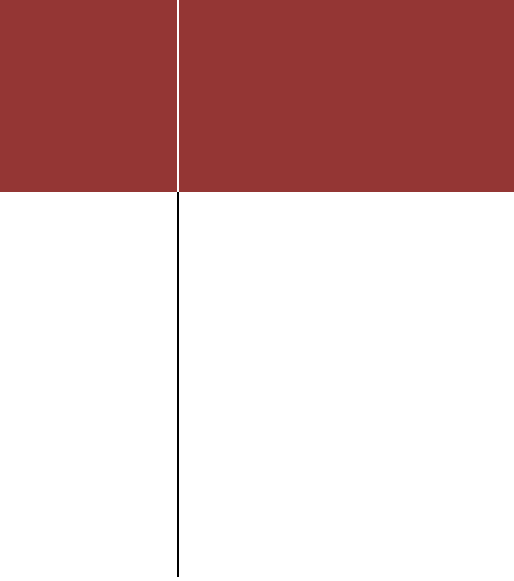
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Yarn manufacturing practical-1

user

Grizli777

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A practical study on:

1. Raw material characteristics
2. Blow room,
3. Carding
4. Draw frame

Machines with their objectives

Raw material characteristics

SOME IMPORTANT POINTS

Cotton is a hygroscopic material, hence it easily adopts to the atmospheric humidity. Air temperature inside the mixing and blow-room area should be more than 25 degree centigrade and the relative humidity (RH%) should be around 45 to 60 %, because high moisture in the fibre leads to poor cleaning and dryness in the fibre leads to fibre damages which ultimately reduces the spinnability of cotton.

In cotton spinning, it is usual practice to mix a few different type of cotton. Also a large number of bales of each cotton type are mixed together. The reasons for mixing are:

- i) Price optimization
- ii) Sufficient quantity of same type of cotton may not be available over a period. In such a situation, substitution of any one variety by somewhat similar growth/type would not generally result in appreciable change in character of yarn. On the other hand, abrupt change of variety in case of single type may change appreciable change in yarn character.
- iii) Cotton is a natural fibre. Properties vary considerably between types of fibre and also between bales of each type. Even variation exists between layers in a single bale in respect of some properties. The variation of the following properties are worth considering.
 - fibre micronaire
 - fibre length
 - fibre strength
 - fibre color
 - fibre maturity
 - trash

Out of these , variation of fibre micronaire, color and maturity results in dye absorption variation. Therefore, it is a good practice to check the maturity, color and micronaire of all the bales and to maintain good Bale Management principles to avoid dye pick up variation and barre in the finished fabric.

BALE MANAGEMENT :(ENGINEERED FIBRE SELECTION SYSTEM)

- While blending of different varieties, it is common practice not to blend cotton types differing in staple length more than 1/16".
- In a particular lot, Micronaire range of the cotton used should be same for all the mixings of a lot.
- Micronaire average of the cotton used should be same for all the mixings of a lot.
- Range of color of cotton used should be same for all the mixings of a lot.
- Average of color of cotton used should be same for all the mixings of a lot.
- Range of maturity coefficient of cotton used should be same for all mixings of a lot
- Average of maturity coefficient of cotton used should be same for all mixings of a lot

In practice, people do not consider maturity coefficient since Micronaire variation and maturity variation are related to each other for a particular type of cotton.

Proper mixing in blow-room takes care of the variations always present between and within bales of same and/or different type of cotton and maintain a uniform yarn and fabric quality. To ensure this, it is necessary to follow these rules:

- To ensure feeding of thin layers from each bale.
- To take maximum number of bales in a mix as this increases the number of layers in a mix.
- Use of good mixing machines in the blow-room line.
- To go for Stack mixing, if possible. It is the best way of doing the mixing compared to using automatic bale openers which picks up the material from 40 to 70 (up to 180) bales depending on the length of the machine and bale size. This is because the Tuft sizes can be as low as 10 grams and it is the best way of opening the material .Nep creation will be less) .Contaminations can be removed before mixing is made. The raw material can get acclimatized to the required temp and R.H.%, since it is allowed to stay in the room for more than 24 hours in an opened state. The fibre gets conditioned well. However some of the disadvantages of stack mixing are
 - more labor is required
 - more space is required

If automatic bale opening machine is used, then the bales should be arranged as follows:

- Suppose there are five different micronaires and five different colors in the mixing, 50 bales are used in the mixing. More groups should be made by grouping the bales in a

mixing so that each group will have average micronaire and average color as that of the overall mixing. The position of a bale for micronaire and color should be fixed for the group and it should be repeated in the same order for all the groups.

- It is always advisable to use a mixing with very low Micronaire range, preferably 0.6 to 1.0.

It is better not to use the following cottons:

- Cottons with inseparable trash (very small size), even though the trash % is less.
- Sticky cotton
- Cotton with low maturity co-efficient

If the cotton is sticky, it would be advisable to use another cotton which is not sticky and to confirm that the cotton is mixed well so that the sticky cotton is spread evenly. Stickiness of cotton is caused by - Honeydew from Whiteflies and aphids and high level of natural plant sugars. The problems with the randomly distributed honey dew contamination often results in costly production interruptions and requires immediate action often as severe as discontinuing the use of contaminated cottons. Natural plant sugars are more evenly distributed and cause problems of residue build up, lint accumulation and roll ups. Quality problems created by plant sugar stickiness are often more critical in the spinning process than the honeydew stickiness. An effective way to control cotton stickiness in processing is to blend sticky and non-sticky cotton.

BLOWROOM

Basic operations in the blow-room:

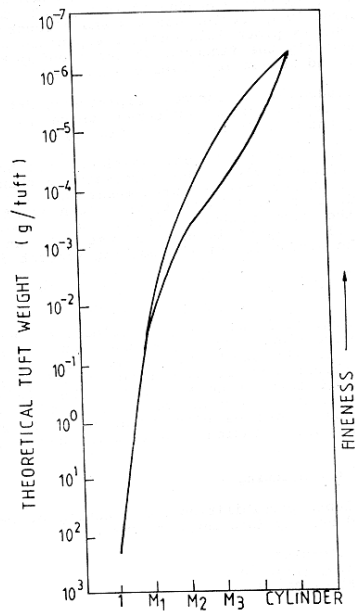
1. opening
2. cleaning
3. mixing or blending
4. micro-dust removal
5. uniform feed to the carding machine

Blow room installations consist of a sequence of different machines to carry out the above said operations. Moreover, since the tuft size of cotton becomes smaller and smaller, the required intensities of processing necessitates different machine configuration.

STEPWISE OPENING AND CLEANING:

OPENING

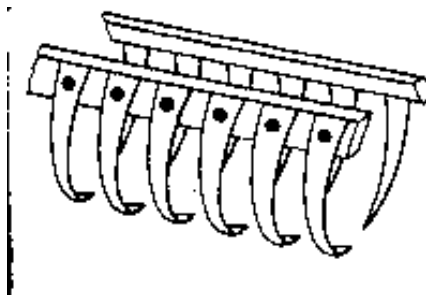
The working hypothesis of opening is illustrated by calculation of the theoretical tuft weight curve starting from the bale, up to the cylinder of carding as shown in the Fig. 1. Tuft size should be purposively graduated.



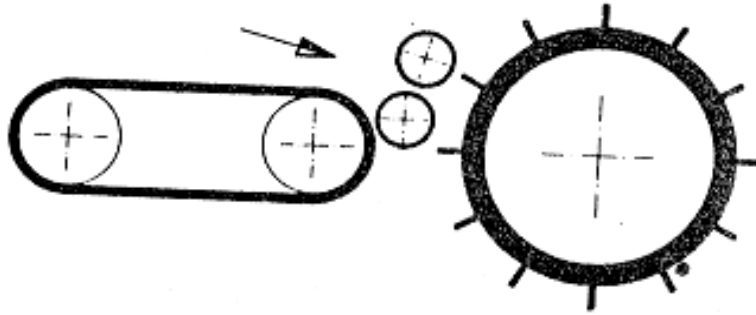
Theoretical tuft weight curve in product

Fig.1

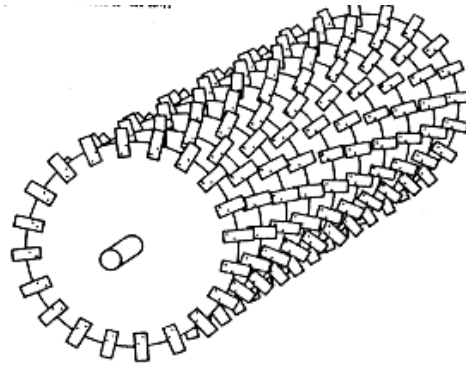
Various Opening devices used in blow-room are shown in the Fig.2



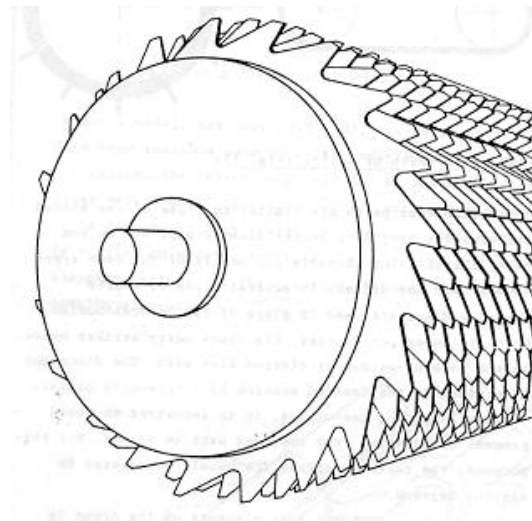
Plucking Springs



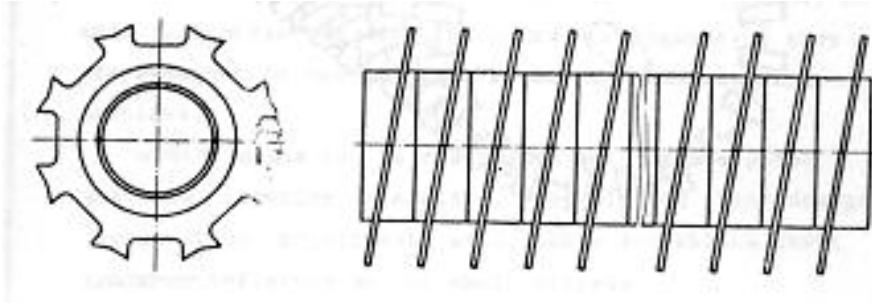
Spiked Roller



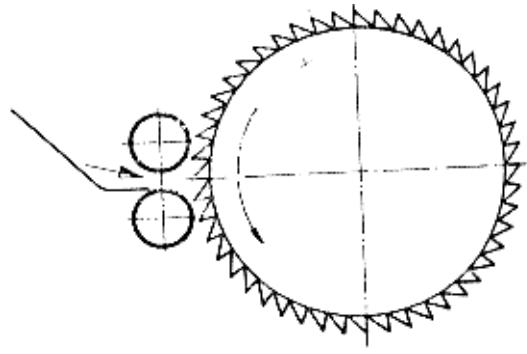
Bladed Drum



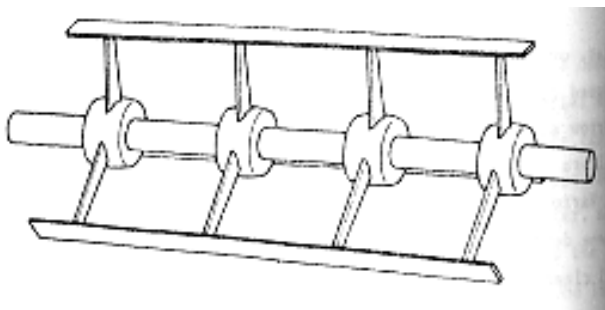
Roller With toothed disc



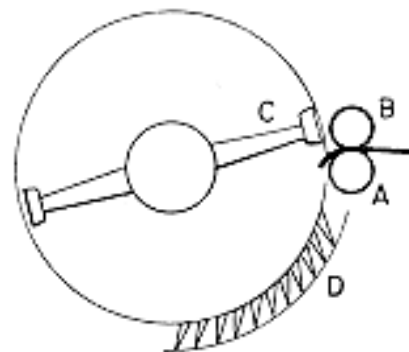
Roller with Toothed disc having double edge



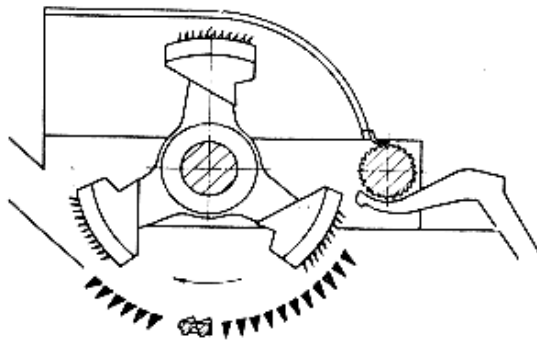
Carding Roller



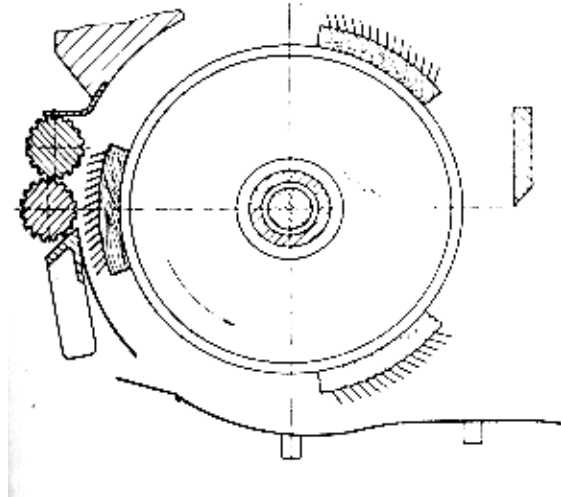
Three Bladed beater



Two Bladed Beater



Kirschner Beater

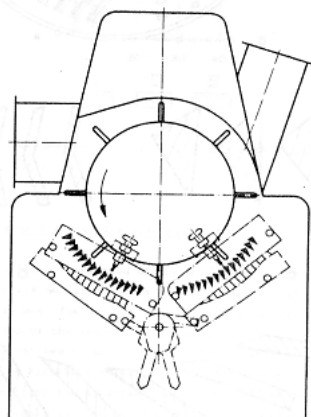


Kirschner Roller

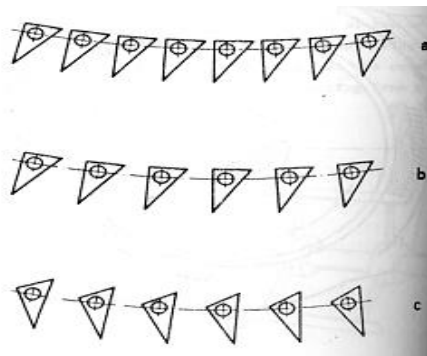
Fig.2

CLEANING:

For cleaning, it is necessary to open more and more surfaces by opening devices and then remove the impurities from the newly created surfaces. Various types of grid bards are used for this purpose in blow room. In addition, air flow is also used to separate the trash from fibres. Suction devices are also used for separation of trash and dust. Various cleaning devices are shown in Fig.3



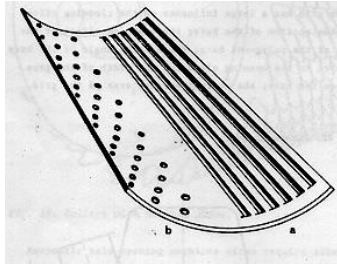
Two part Grid



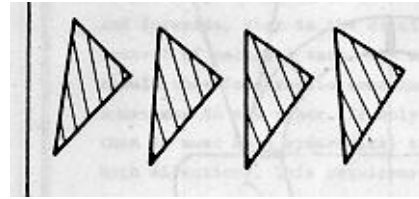
a: closed b: open c: aggressive angle

Grid Adjustment

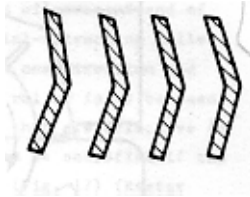
Cleaning by Grids



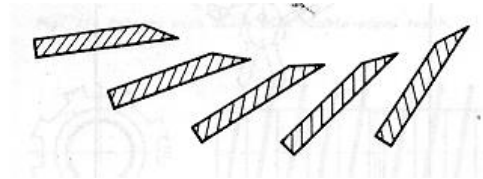
Slotted Sheet and perforated Sheets



Triangular Sectional bars



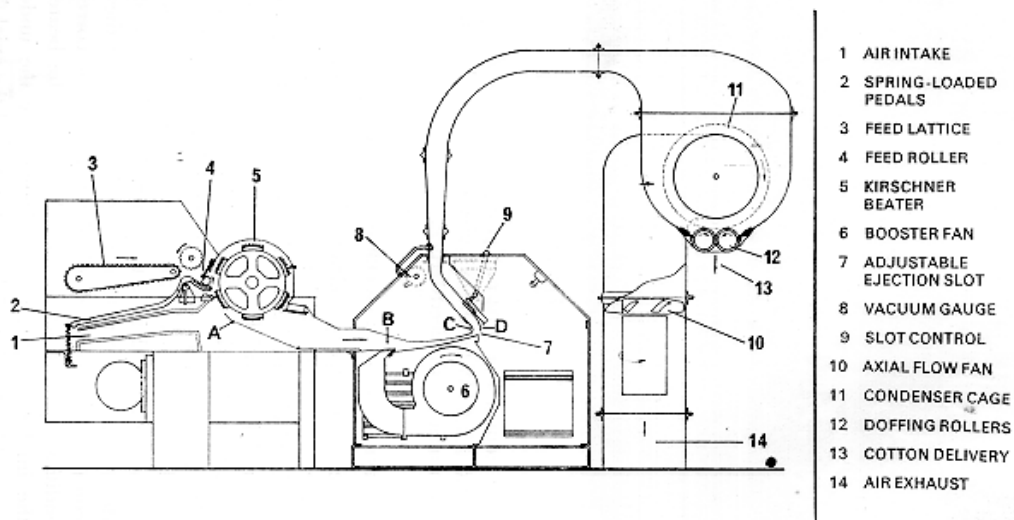
Angle bars



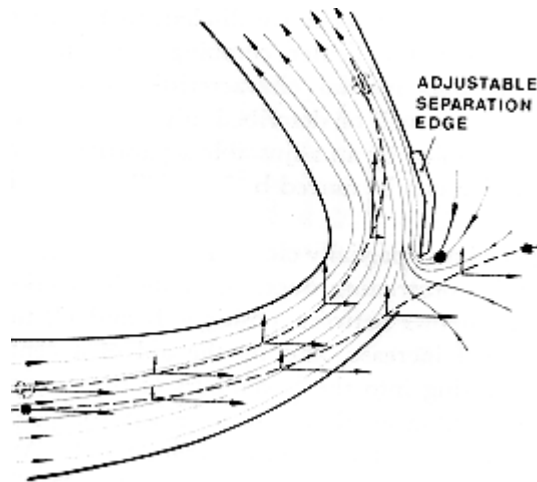
Blades

Various Types of Grids

Cleaning by Air



Air Stream Cleaner



Flow Diagram in the Air Stream Cleaner

Fig.3

In combination with opening in cleaning, the following procedures can be used:

Striking:	results in	Falling out
Beating:	results in	Ejecting
Scraping	results in	Separation
Suction:	results in	Separation
Combing:	results in	Extraction
Use of centrifugal force:	results in	Ejection

Striking carried out by pins, noses etc. present on the opening devices, leads to repeated collisions of the flocks with the grid bars, causing foreign particles to drop down.

In beating, the flocks are subjected to a sudden strong blow. The inertia of the impurities, accelerated to high speed is substantially greater than that of the opened flocks. As a result they pass between grid bars in to the waste box.

Impurities can be scrapped off when the fibres are guided under relatively high suction over the grid bars, mote knives etc. This is particularly important for dust removal.

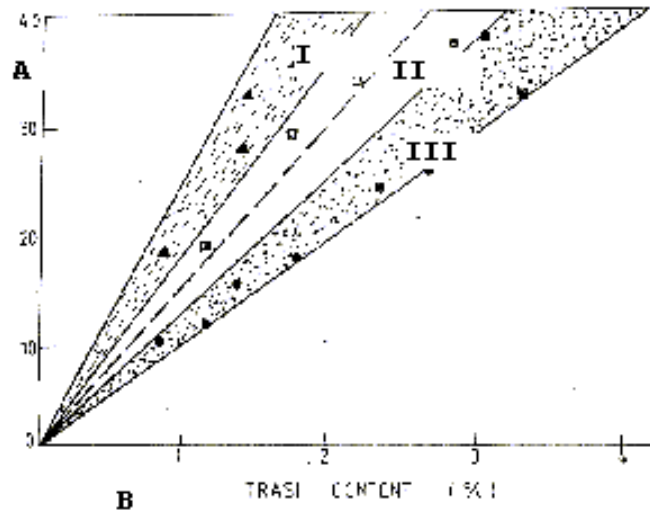
Suction is more suited for elimination of finer trash and dust.

In combing, the needles or saw toothed wires pass through the body of fibres and draw impurities out of the inner regions. This is the only mechanical operation in which regions other than simple surface are cleaned.

Centrifugal for is used in separating impurities from fibres in card cylinder. This principle is also used in many modern fine cleaning machines in modern blow-room.

SOME TECHNOLO POINTS CONNECTED TO OPENING AND CLEANING

- The larger the dirt particle , the better they can be removed
- Since almost every blow-room machine can shatter particles, as far as possible a lot of impurities should be eliminated at the start of the process. Opening should be followed immediately by cleaning, if possible in the same machine.
- Higher the degree of opening results in higher the degree of cleaning. A very high cleaning effect is almost always purchased at the cost of a high fibre loss. Higher roller speeds give a better cleaning effect but also more stress on the fibre.
- Cleaning is made more difficult if the impurities of dirty cotton are distributed through a larger quantity of material by mixing with clean cotton.
- The degree of cleaning is strongly dependent on the TRASH % (as shown in Fig.4). It is also affected by the size of the particle and stickiness of cotton. Therefore, cleaning efficiency can be different for different cottons with the same trash %. Different cottons have different cleaning resistance.(as shown in Fig.4) although they may have same Trash %.
- Due to machine harvesting, cotton contains more and more impurities, which furthermore are shattered by hard ginning. Therefore cleaning is always an important basic operation in modern blow-room
- Mechanical action on fibres causes some deterioration on yarn quality, particularly in terms of neps . Moreover, staple length of cotton can be significantly shortened .
- By using a much shorter machine sequence, fibres with better elastic properties and improved spinnability can be produced.
- Air streams are often used in the latest machine sequence to separate fibres from trash particles by buoyancy differences rather than beating the material against a series of grid bars. Trutzchler cleanomat is an example.



A: Degree of cleaning of the machines; B: Dirt content of cotton; I: zone of low resistance; II: zone of medium resistance; III: zone of high resistance

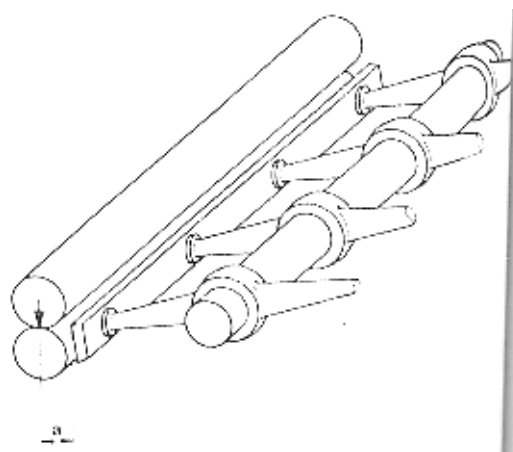
Fig.4

FEEDING DEVICES

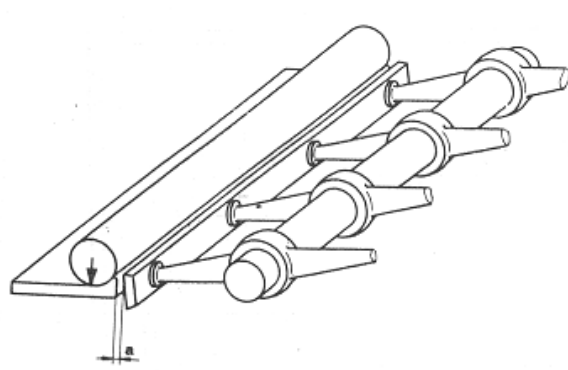
There are three types of feeding apparatus in the blow-room machines

1. Two feed rollers(clamped)
2. Feed roller and a feed table
3. A feed roller and pedals

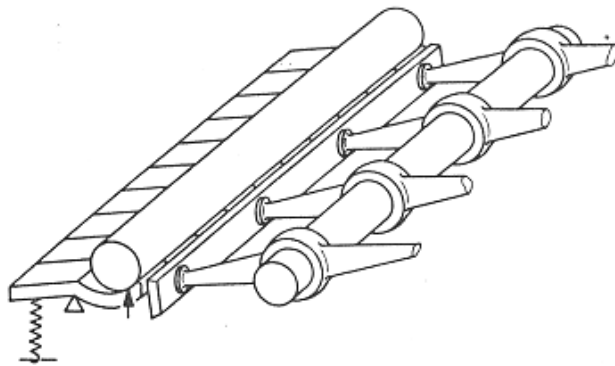
These are shown in Fig.5



Feeding by two rollers



Feed by roller and table



Feeding with a roller and pedals

Fig.5

- Two feed roller arrangement gives the best forwarding motion, but unfortunately results in greatest clamping distance between the cylinders and the beating element
- In a feed roller and table arrangement, the clamping distance can be made very small. This gives intensive opening, but clamping over the whole width is poor, because the roller presses only on the highest points of the web. Thin places in the web can be dragged out of the web as a clump by the beaters.
- Feed roller and pedal arrangement gives secure clamping throughout the width and a small clamping distance, which is very critical for an opening machine.

General factors which affect the degree of opening , cleaning and fibre loss are,

1. thickness of the feed web
2. density of the feed web
3. fibre coherence
4. fibre alignment

5. size of the flocks in the feed (flock size may be same but density is different)
6. the type of opening device
7. speed of the opening device
8. degree of penetration
9. type of feed (loose or clamped)
10. distance between feed and opening device
11. type of opening device
12. type of clothing
13. point density of clothing
14. arrangement of pins, needles, teeth
15. speeds of the opening devices
16. throughput speed of material
17. type of grid bars
18. area of the grid surface
19. grid settings
20. airflow through the grid
21. condition of pre-opening
22. position of the machine in the machine sequence
23. ambient R.H. %
24. ambient temperature

DEGREE OF CLEANING:

Degree of cleaning of the machine is the ratio of the trash removed by the machine to that of total trash fed to the machine, expressed as percentage

Degree of cleaning = $\frac{(\text{trash in feed \%} - \text{trash in del \%}) \times 100}{(\text{trash in feed \%})}$

- Following are the basic parameters to be considered in Blowroom process.

Cleaning Efficiency:

Cleaning Efficiency: $= \frac{(\text{Trash in Waste}) \times 100}{(\text{Total Waste})}$

DUST REMOVAL

- Cotton contains very little dust before ginning. Dust is therefore caused by working of the material on the machine. New dust is being created through shattering of impurities and smashing and rubbing of fibres. However removal of dust is not simple. Dust particles are very light and therefore float with the cotton in the transport stream. Furthermore the particles adhere quite strongly to the fibres. If they are to be eliminated they are to be rubbed off. The main elimination points for adhering dust therefore, are those points in the process at which high fibre/metal friction or high fibre/fibre friction is produced.
- Removal of finest particles of contaminants and fibre fragments can be accomplished by releasing the dust into the air, like by turning the material over, and then removing the dust-contaminated air. Release of dust into the air occurs wherever the raw material is rolled, beaten or thrown about. Accordingly the air at such positions is sucked away. Perforated drums, stationary perforated drums, , stationary combs etc. are some instruments used to remove dust.

SEQUENCE OF OPERATION IN BLOW ROOM

Since blow-room machines have to fulfill various functions, they also vary in concept and design. Basically the following types are found:

Bale Opening machines

Cleaning machines

Mixing machines

Dust extraction machines

Metal, fire and foreign fibre (optional) detection machines.

Either lap formation unit or Chute feed to card

In order to perform their assigned tasks properly, these machines must be located on a quite specific location in the blow room line. In a normal modern blow room line, five distinguished operating zones can be identified.

Dust removal and other detection machines can not be allocated to any single zone. Dust removal is carried out more or less in each blow room machine, as a side effect. However several manufacturers now offer special dust removing machines. In machine sequence, they appear mostly at the end of the blow room line.

Even though machines within an individual zone differ in design, they are based on common concept so that all the machines of a given zone can be in general explained by taking a few of them as examples.

The following are the five common zones of processing in a modern blowroom

- | | |
|---|--------|
| 1. Bale opening (Pre opening)- | Zone-1 |
| 2. Coarse Cleaning(Pre cleaning) | Zone-2 |
| 3. Mixing or blending | Zone-3 |
| 4. Fine opening and cleaning | Zone-4 |
| 5. Chute Feeding or in some cases lap formation in scutcher | Zone-5 |

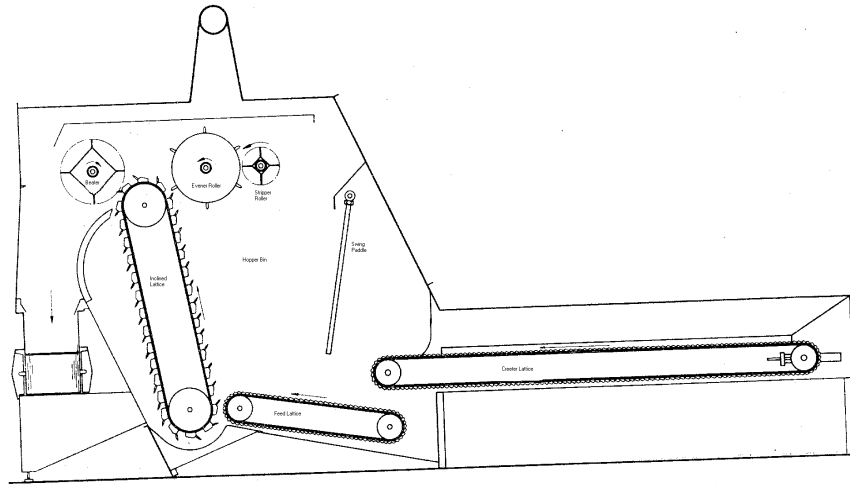
ZONE-1 : BALE-OPENING(OR PRE-OPENING):

Effective pre-opening results in smaller tuft sizes, thus creating a large surface area for easy and efficient removal of trash particles by the fine openers.

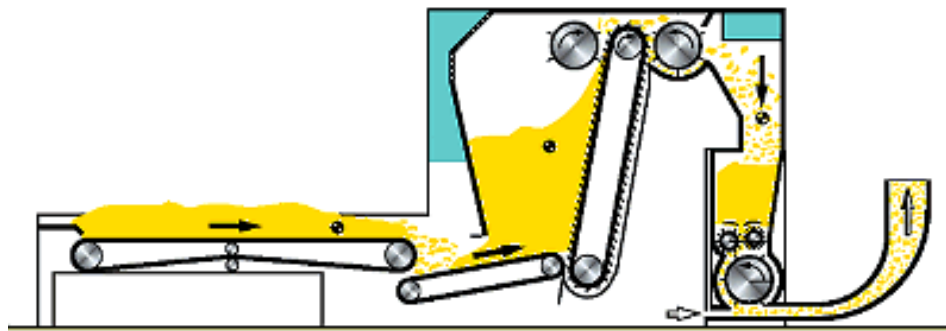
The machine of this zone should be able to

- Extract the material evenly from the bales
- Open the material gently
- Open up to the smallest flocks
- Form flocks of equal size.
- Process as many bales as possible in a single charge
- Blend material right at the start of the process

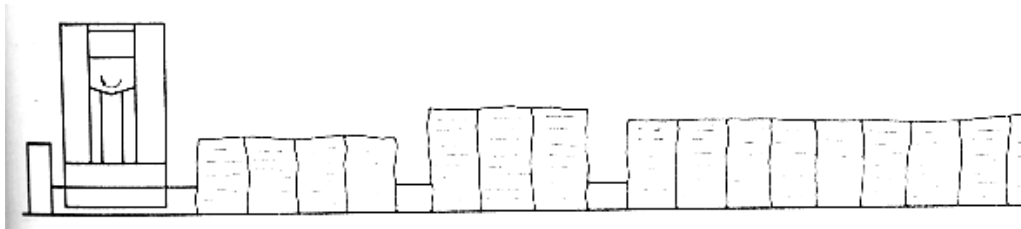
Some of these machines are shown in **Fig.6**



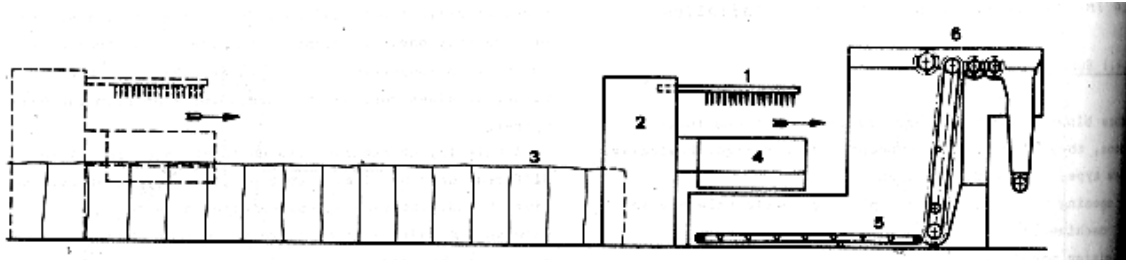
Conventional Hopper Bale Breaker



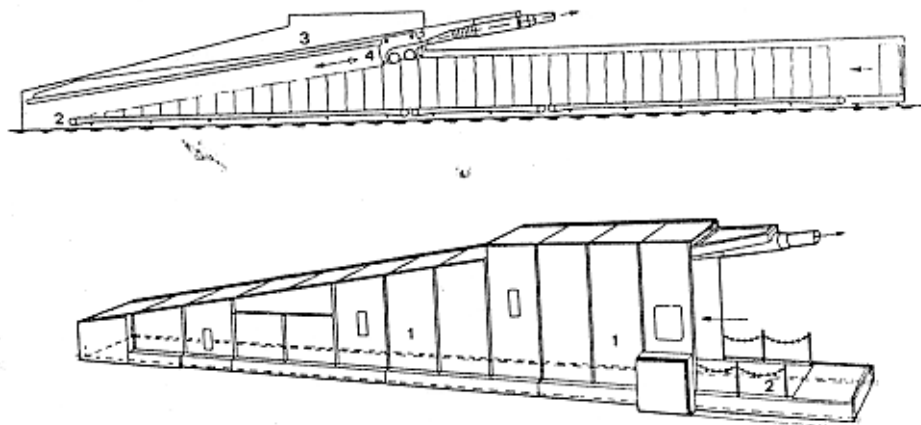
Modern machine working on similar principle



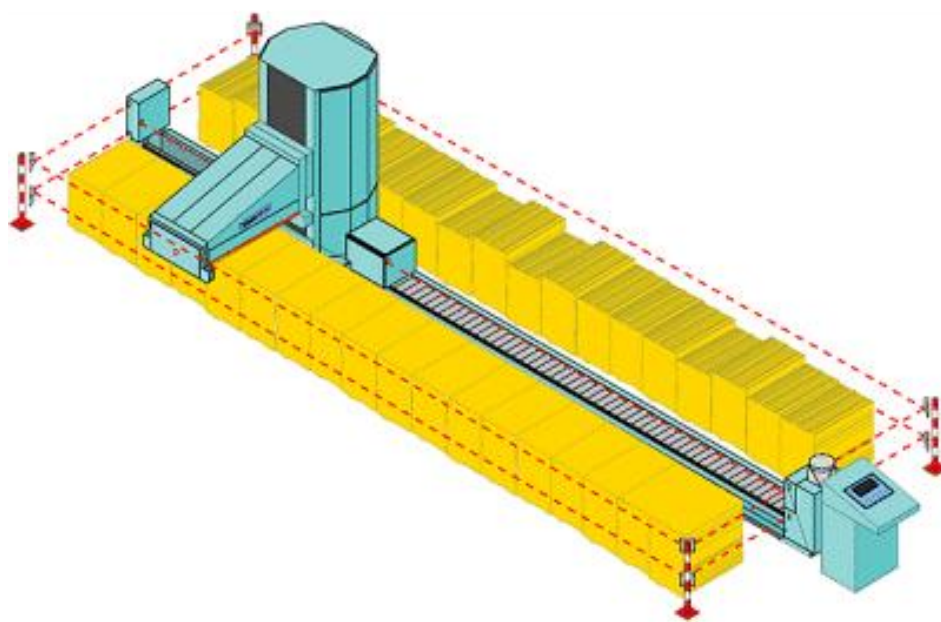
Automatic Bale opening from different component(type) of fibre



Automatic bale opening machine of Schubert and Salzer (Blending Grab) 1. spring grab 2. carriage 3. bales 4. weighing container 5.conveyer 6. blending opener



Multiple Bale Opener MO IV of Hergeth Hollingsworth



BLENDOMAT BDT 019 of Trutzchler



BLENDOMAT BDT 020 of Trutzchler

Fig.6

If Spike Lattice Action is used for bale opening then

- The inclined lattice speed and the setting between inclined lattice and clearer roller decides the production of the machine
- The setting between inclined lattice and clearer roller decides the quality of the tuft .If the setting is too close, the tuft size will be small, but the neps in the cotton will be increased due to repeated action of the inclined lattice pins on cotton. The clearance should be decided first to confirm the quality, then inclined lattice speed can be decided according to the production required.The setting of inclined lattice depends upon the fibre density, fibre micronaire and the tuft size fed. If smaller tuft is fed to the feeding conveyor, the fibre tufts will not be recycled many times, hence the neps will be less.
- This machine is not meant to remove trash , hence the fibre loss should also be less.
- It is easier to remove the bigger trash than the smaller trash, therefore enough care should be taken to avoid breaking the trash particles
- This machine is just to open the tufts into small sizes so that cleaning becomes easier in the next machines.
- The fibre tuft size from this machine should be preferably around 100 to 200 milligrams.

If Automatic Bale Openers such as Uniflco11 (Rieter) or Blendomat BDT 019(Trutzschler) or Marzoli B12SB or similar machines are used as a first zone machine, then

- It helps to maintain the homogeneity of the long term blending.
- Cotton is opened gently without rolling as it is done in manual bale openers
- With the latest automatic bale opening machines, the tuft size can be as small as 50 to 100 grams without rupturing the fibres
- The opening roller speed should be around 1500 to 1800 rpm.

- The depth of penetration of the opening should be as minimum as possible for better quality
- Production rate of this machine depends upon the no of mixings working at the same time
- Production rate depends upon opening roller depth, traverse speed and the fibre tuft density in the bale.

ZONE-2: COARSE-CLEANING:

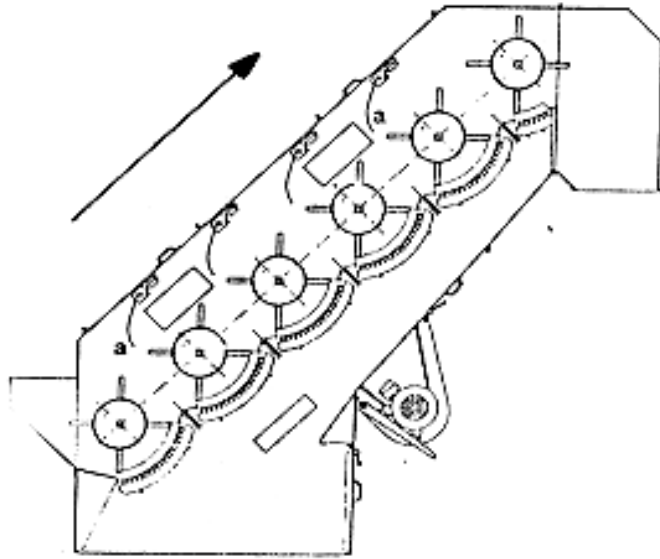
Two things are conspicuous in coarse cleaning machines:

- They generally process the material while it is in free flight.
- The striker elements are widely spaced on the operating rollers.

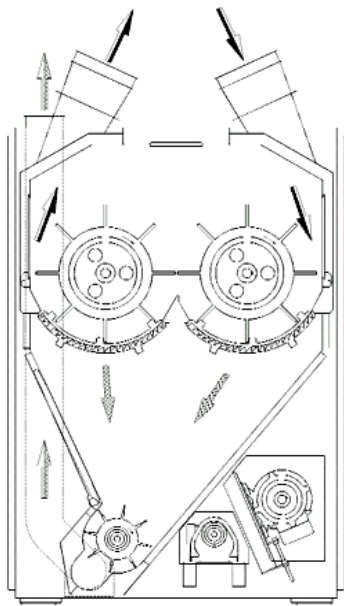
The opening effect is correspondingly very small. This is acceptable in zone 2 as surface area is already created before this stage by opening machines in zone-1. The opening machines themselves cannot clean these surfaces because they are not fitted with cleaning devices or they can eliminate only a fraction of impurities due to high material throughput.

Coarse-cleaning should be gentle. Since removing finer trash particles is difficult, seeds and bigger trash particles should not be broken. Finer trash particles require severe treatment in fine openers. This will lead to fibre damage and more nep generation. Therefore, pre-cleaning should be as gentle as possible. If pre-opening and pre-cleaning are done properly, consistency in trash removal by fine openers is assured. Dust removal should be started in this machine.

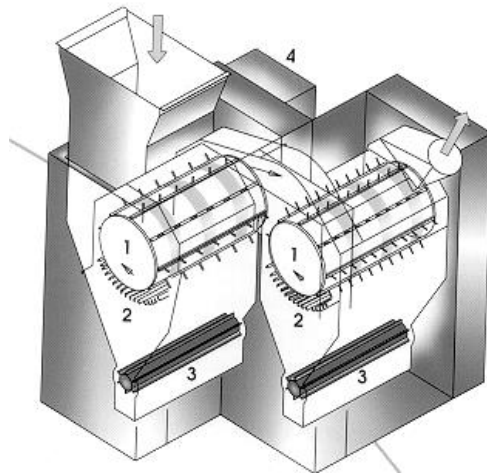
Step cleaner, Rieter monocylinder cleaner or more recent Rieter's Uniclean B11, Trutzschler's Axiflow(AFC) or more recent Maxiflow(MFC), Marzoli B31/1 or recent B19 are the machines which do this work. Some of these machines are shown in **Fig.7**. MFC and B39 are similar machines working with two rollers.



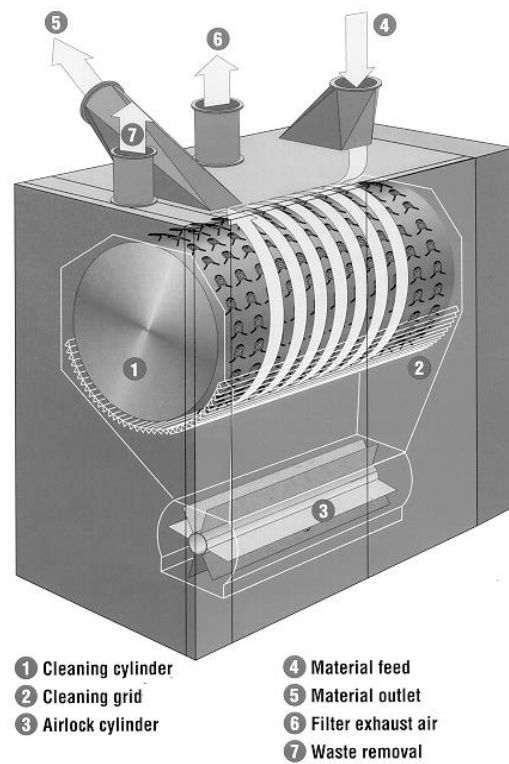
Step Cleaner



Trutzchler MFC



Marzoli B39



Rieter Uniclean B11

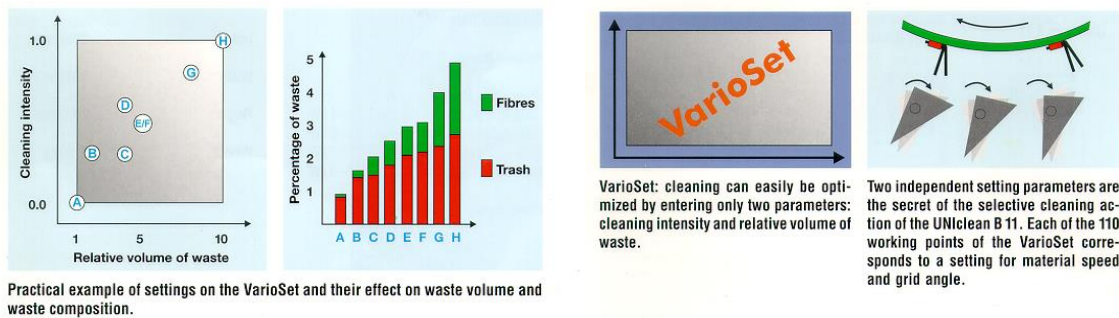


Fig.7

- The fibre treatment in zone-2 machine is very gentle because the fibres are not gripped by the feed roller during beating. Fibre tufts treated by the pin beater when it is carried usually by air medium.
- All heavy trash particles fall down before they are broken
- Mostly all heavy seeds(full seeds) fall in this machine without any problem

- Around 50 pascal suction pressure should be maintained in the waste chamber for better cleaning efficiency
- Beater speed, resident time (air velocity through the machine), grid bar setting and gap between grid bars will affect cleaning. Higher the degree of cleaning, higher the good fibre loss, higher the nep generation and higher the fibre rupture. The optimum point is shown in Fig. 8 as given by Rieter.
- The optimum cleaning means maximum cleaning performance, minimum loss of good fibres, a high degree of fibre preservation and minimum nep generation
- Rieter has a unique concept called "VARIOSET". With this machine, selective trash removal is possible. Waste amount and cleaning intensity can be set as shown in Fig above and accordingly cleaning desired can be adjusted.

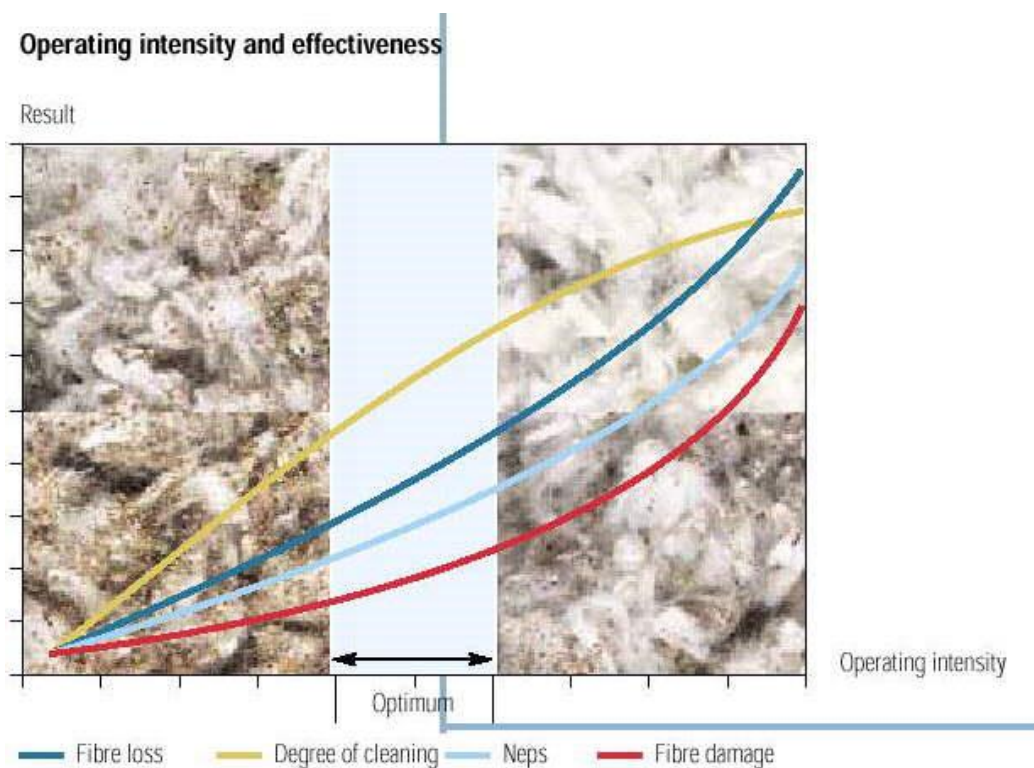


Fig 8 (form Rieter) which shows, degree of cleaning, fibre loss, neps, fibre damage.

- With normal machines like mono-cylinder or axiflow, a lot of trials to be conducted to arrive at optimum beater speed, air velocity (fan speed), grid bar setting and grid bar gap.

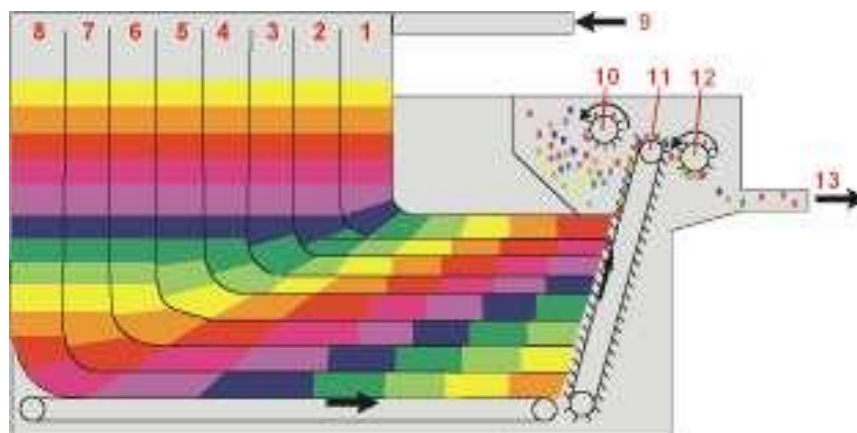
- In general the beater speed is around 750 and minimum 50 pascal suction pressure to be maintained in the suction chamber

ZONE-3 MIXING AND BLENDING:

Barre or streakiness in fabric arise due to uneven mixing of different cottons. Hence mixing technology is a decisive factor in spinning mill technology. Bigger the differences of cotton parameters like fineness, color and staple length, the greater the importance of mixing. If the cotton has honeydew, the intensive mixing of the raw material is a precondition for an acceptable running behavior of the complete spinning mill. The following machines are used in this zone:

- Mixing battery
- Multiple mixer of Hollingworth, MCM/MPM of Trutzchler, Automixer B143 of Marzoli or similar machines. Here chutes are filled successively and material is removed simultaneously.
- Unimix B70 of Rieter or similar machines where time delay technique is used for achieving mixing.

Some of these machines are shown in Fig.9 . For blending of different fibres, either blending battery with weighted pan or machines such as Rieter Uni-blend A80 or similar machines are used. These are shown in Fig.10



Rieter Uni-Mix

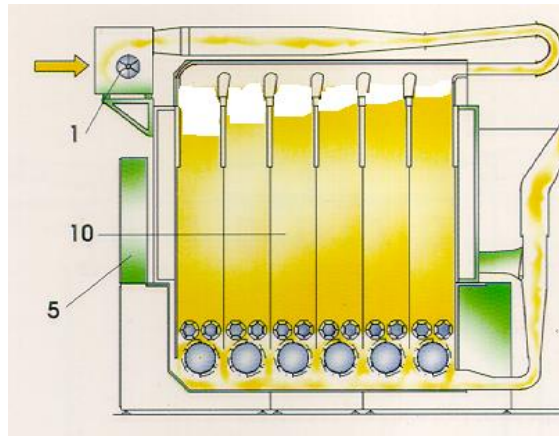
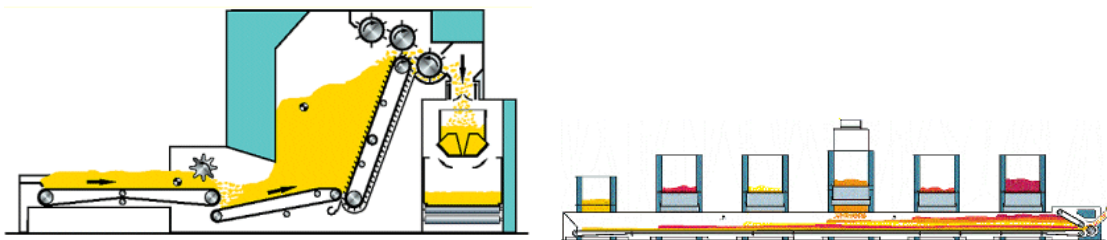
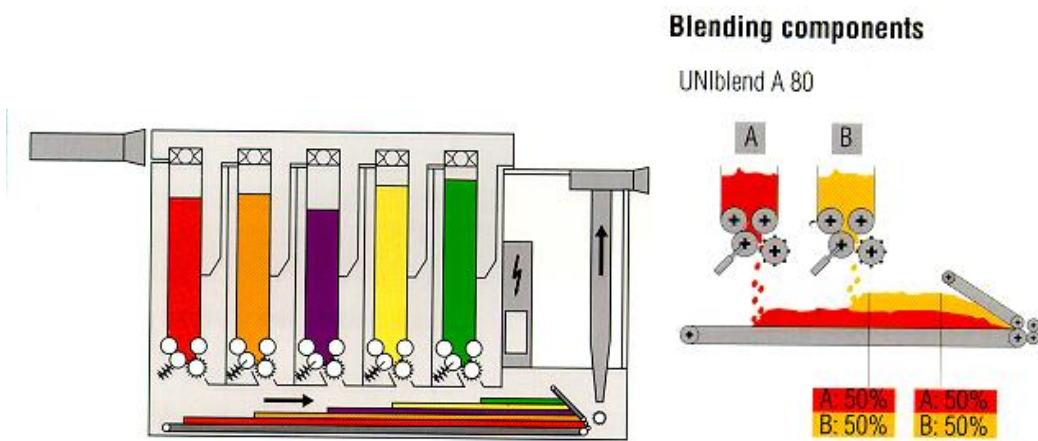


Fig.9



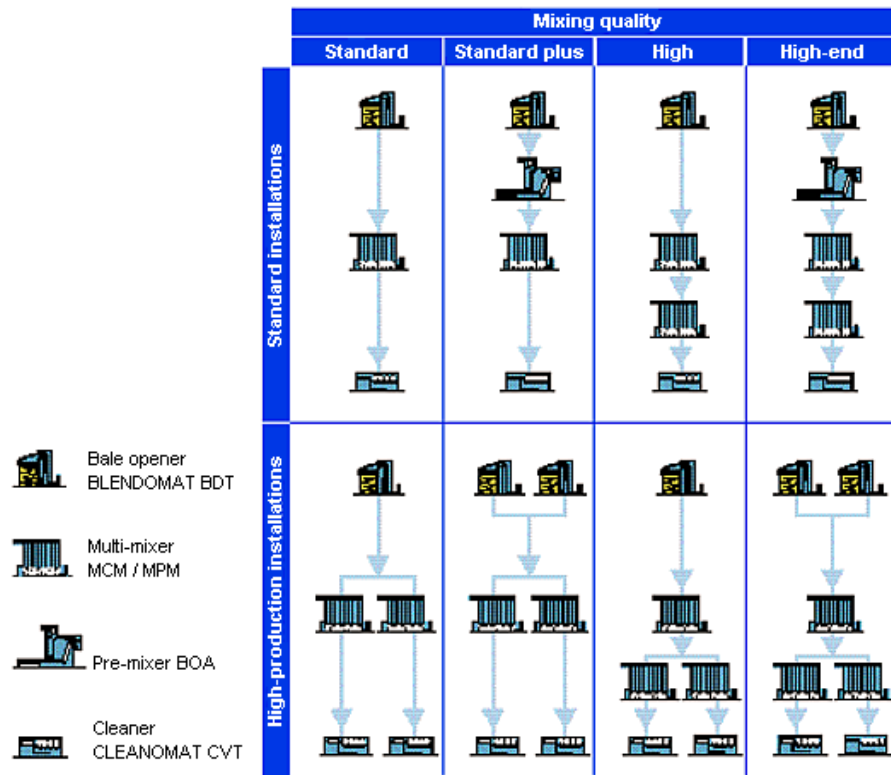
Trutzchler Blending battery for Tuft blending



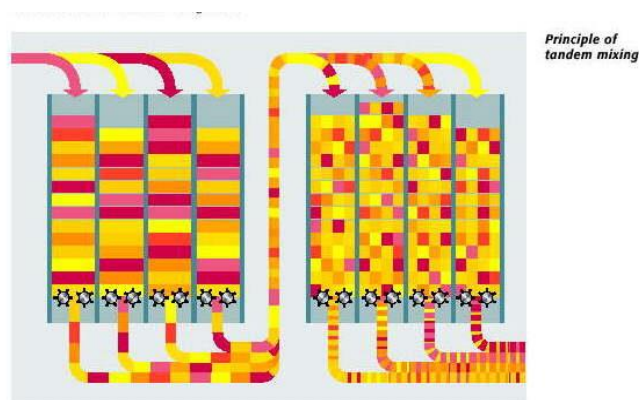
Uniblend A80 of Rieter

Fig.10

Following fig. is given by Trutzschler for different mixing requirements



- Trutzschler's tandem mixing concept is a good solution, if the mixing requirement is very high. This principle guarantees a maximum homogeneous of the mix



Tandem mixing concept from TRUTZSCHLER:

FIG.11

ZONE-4 FINE CLEANING:

In contrast to zone-2 machines, those of zone-4 must again produce new surfaces and as far as possible very small tufts with large total surface area, ie. cleaning operation must be preceded by opening. Zone-4 machines always operate with clamp feed. Also, the spacing of the striker elements on the rollers must be finer. The well known horizontal cleaner is an example. Rieter Uniflex B70 is another example. In Trutzchler new cleanomat series of cleaners, suction hood and deflector blade is used instead of grid bars(Fig.11).

If single roller cleaning machines are used, depending upon the amount and type of trash in the cotton, the number of fine cleaning points can be either one or two.

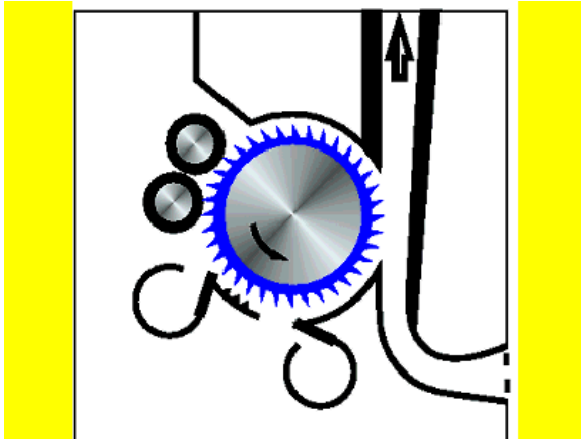
Normal beater speeds with single roller saw-tooth beater depends upon the production rate, fibre micronaire and trash content.

TYPE OF COTTON	COTTON MICRONAIRE	PRODUCTION RATE kgs/hr	BEATER SPEED rpm
more trash	3.5 to 4.0	200 to 300 kgs /hr	600 to 750
less trash	3.5 to 4.0	200 to 300 kgs/hr	600 to 750
more trash	4.0 to 4.5	200 to 300 kgs	700 to 850
less trash	4.0 to 4.5	350 to 500 kgs	1000 and above

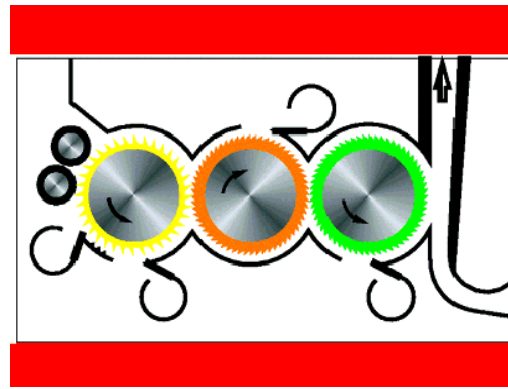
The number of wire points depends on the production rate and trash.

Setting between feed roller and beater depends on the production rate and micronaire. The setting should be around 2 to 3 mm.

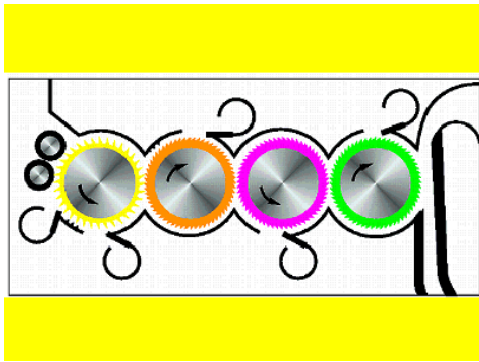
Closer the setting between beater and mote knives, higher the waste collected. It is advisable to keep around 3 mm.



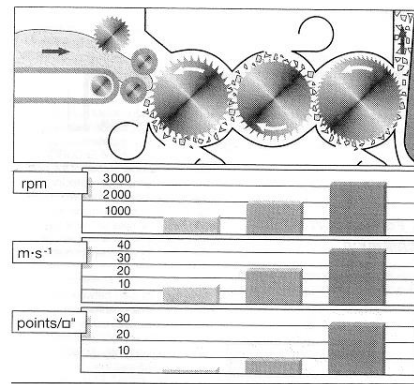
Cleanomat CVT-1 of Trutzchler



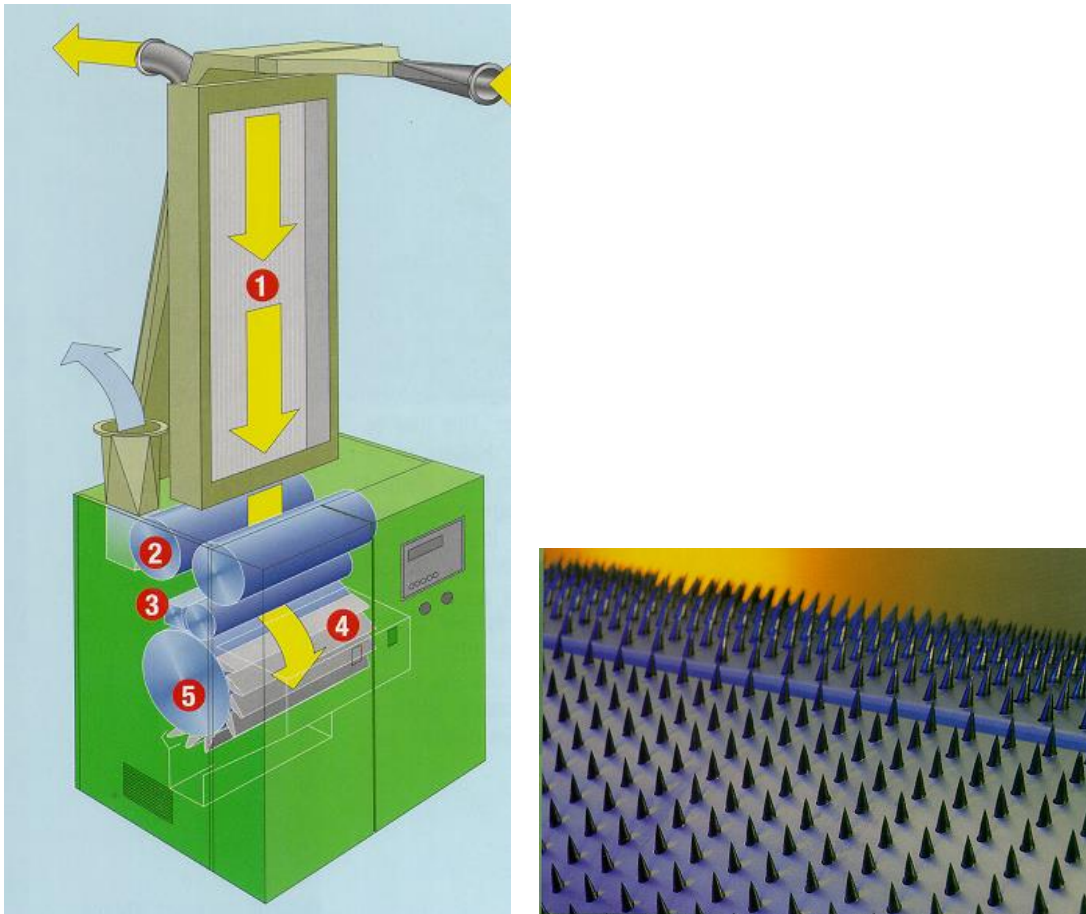
Cleanomat CVT-3 of Trutzchler



Cleanomat CXL of Trutzchler



RPM, Surface Speed and Number of Wire points in the rollers



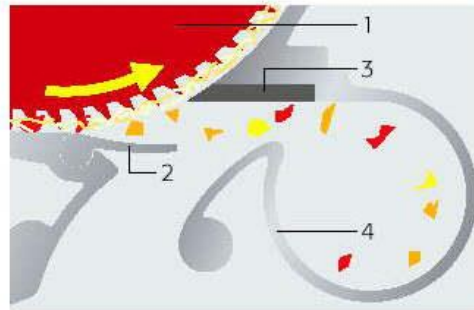
1: Lamina Chute; 2: Perforated drum; 3: Adjustable feeding through; 4: Adjustable grid; 5: Opening and Cleaning roller

Rieter Uniflex B70

Fig.11

- The cleaning points in CVT1, CVT3, CVT4 etc consists of opening roller, deflector blades, moteknives and suction hood. Trash particles released due to centrifugal forces are separated at the moteknives and continuously taken away by the suction. This gives better cleaning

- 1 Cleaning roll
- 2 Deflector blade
- 3 Mote knives
- 4 Suction hood



trash removal concept in CVT cleaners:

Fig.12

Suction plays a major role in these machines. If suction is not consistent, the performance will be affected badly. Very high suction will result in more white fibre loss and less suction will result in low degree of cleaning.

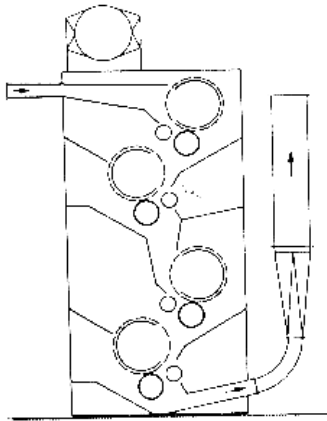
The minimum recommended pressure in the waste chamber (P2) is 700 pascals. It can be up-to 1000 pascals.

Wider the deflector blade setting, higher the waste. If the setting is too wide, white fibre loss will be very high.

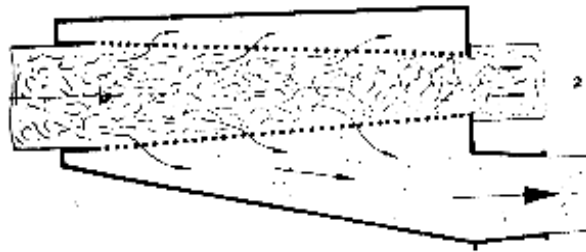
DE-DUSTING:

Apart from opening and cleaning of raw-material, de-dusting is the very important process in blowroom. As discussed already, normally de-dusting starts with precleaning and this is done along with trash separation in many machines. Fine openers like ERM, CVT cleaners help in de-dusting effectively. Still it is always better to have a separate machine like DUSTEX of TRUTZSCHLER for effective dedusting, particularly for rotor spinning line. This machine is shown in Fig.13. De-dusting keeps the atmospheric air clean. Stationary de-dusting condensers

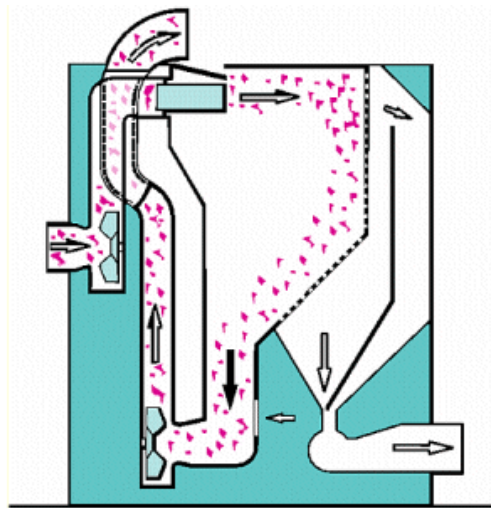
can also be used for this purpose as shown in Fig.13. In exhausts of unimix , condensers , ERM etc, positive pressure of 100 pascal should be maintained. Exhaust fan speed and volume should be accordingly selected. DUSTEX or some other special de-dusting machine should be installed before feeding to the cards, because better the fibre opening better the de-dusting.



Hergeth Hollingsworth dust remover



Rieter Dust Extractor



Trutzchler dustex DX

Fig.13 Some dust extracting devices

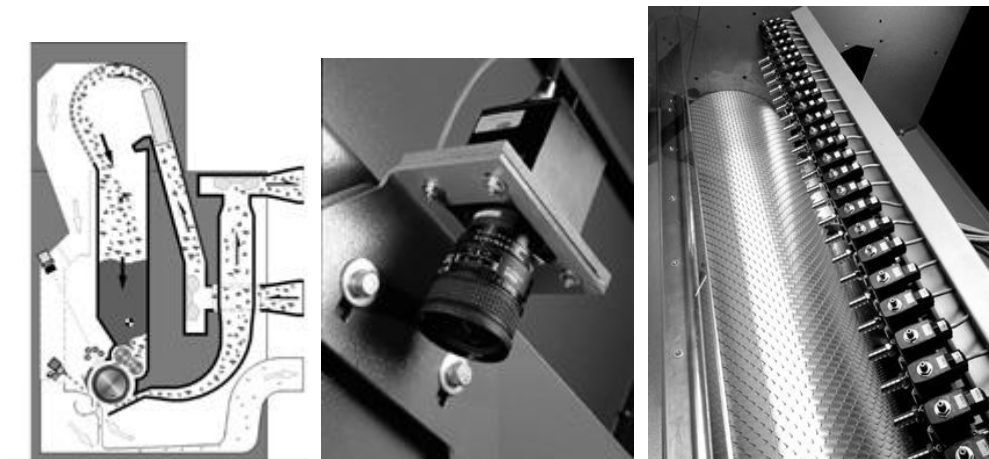
ASSOCIATED EQUIPMENTS:

Magnetic extractors: This is used in order to remove ferrous metals mixed with material.

Fire eliminators: This comprises spark detectors and eliminating device.

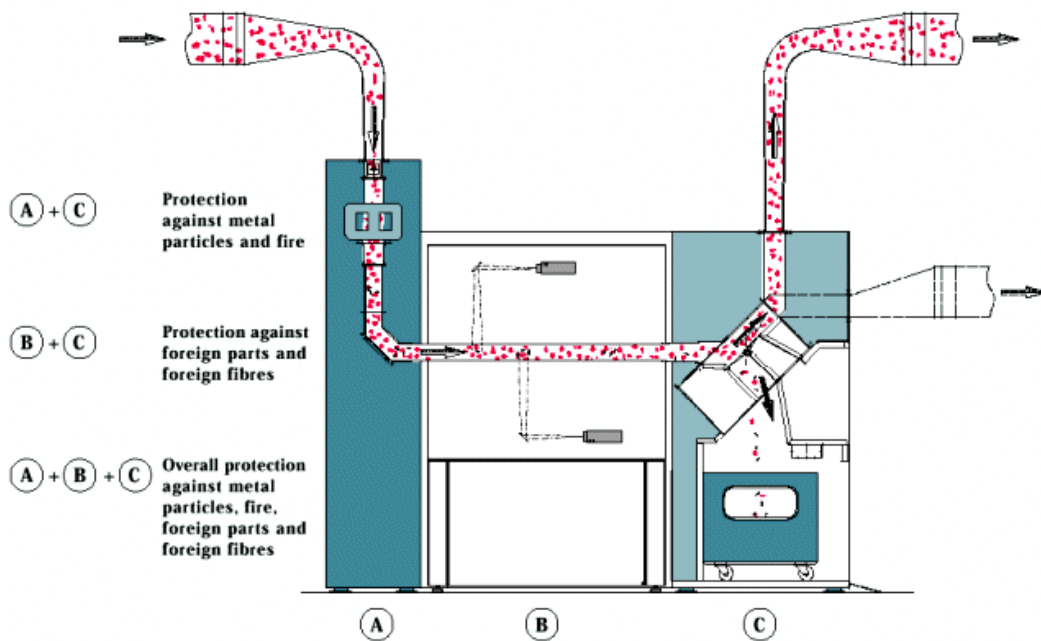
Foreign matter detectors: It would intercept foreign matter in the opening and cleaning line, i.e. at the very beginning of the spinning process in order to prevent fibrous contaminants from becoming fibrillated and dispersed. These systems are based on CCD camera or electro-optical sensor technology. Cotton tufts are scanned while being conveyed by airflow and contaminated lint is separated via diverters or compressed air nozzles. Truetzschler's Securomat SCFO is such a system which is placed at the end of the blow-room line(Fig14). At that position, tuft size is minimal and to further enhance system resolution. A CCD color line scan camera monitors the surface of a rotating spiked cylinder. Among the tiny tufts and individualized fibers present on the cylinder surface, even the smallest contaminants are exposed and distinctly presented to the camera system. Upon exceeding certain camera signal limits, pneumatic valves and compressed air nozzles are activated and the foreign object is ejected into the waste duct.

Fig. 15 shows a modular design from Truetzchler for detection and separation of metal, heavy particles, fire and foreign fibres.



Schematic view of Securomat SCFO CCD color line scan camera Compressed air
ejection nozzles

Fig.14



Securomat SC from Trutzchler

Fig.15.

SOME GENERAL RECOMMENDED PROCESS CONDITIONS IN BLOW-ROOM

- It is advisable to run the fans at optimum speeds. Higher fan speeds will increase the material velocity and will create turbulence in the bends. This will result in curly fibres which will lead to entanglements.
- If the production rate per line is high, the reserve chamber for the feeding machine should be big enough to avoid long term feed variations.
- It is advisable to reduce the number of fans in the line.
- Fan speeds, layout of machines should be selected in such a way that material choking in the pipe line, beater jamming etc will not happen.

- All blow-room machines should work with maximum efficiency. The feed roller speeds should be selected in such a way that it works at least 90% of the running time of the next machine.
- Heavy particles like metal particles, stones should be removed using heavy particle removers , double magnets etc, before they damage the opening rollers and other machine parts.
- Number of cleaning points are decided based on type of ginning (whether roller ginned or saw-ginned), the amount of trash, and the number of trash particles and the type of trash particles.
- Machinery selection should be based on the type of cotton and production requirement.
- Material level in the storage chambers should be full and it should never be less than 1/4th level.
- Grid bars should be inspected periodically, damaged grid bars should be replaced. Grid bars in the front rows can be replaced earlier
- If the cotton is too sticky, the deposits on the machine parts should be cleaned at least once in a week, before it obstruct the movement of the fibre
- Fibre rupture should be checked for each opening point. 2.5 % span length should not drop by more than 3%. If the uniformity ratio drops by more than 3%, then it is considered that there is fibre rupture.
- High fan speed, which will result in high velocity of air will increase neps in cotton
- Nep increase in the blow-room should not be more than 100%.
- The nep increase in each opening machine should be checked with different beater speeds and settings, and the optimum parameters should be selected. But it is necessary to remember that everything should be based on yarn quality checking. e.g. if nep increase in blow room is more and the beater speed or feed roller setting is changed, the tuft size will become more. This may result in bad carding quality. Sometimes if the neps are slightly more and the fibre is well opened, the neps can be removed by cards and

combers and the yarn quality may be better. Therefore all trials should be done up-to yarn stage. No of neps and trash particles after different processes is given below.(an approximate value)

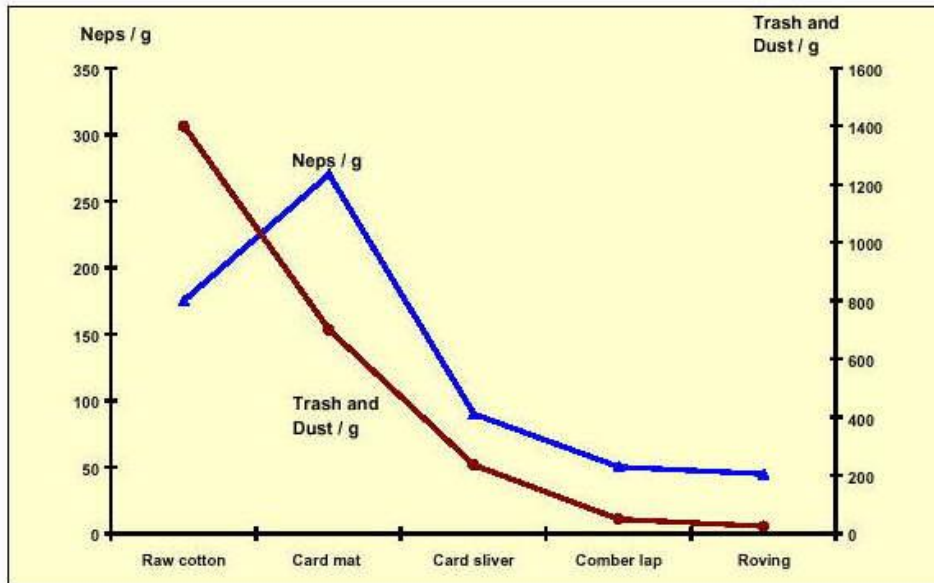
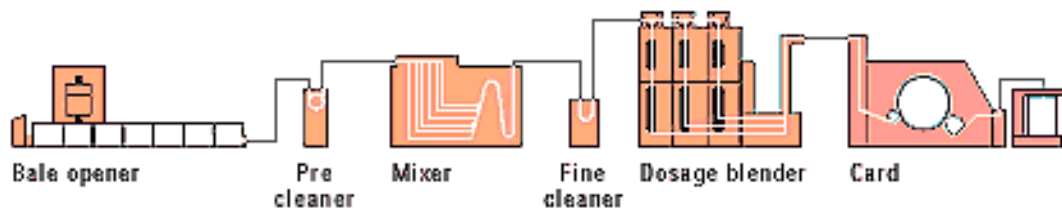
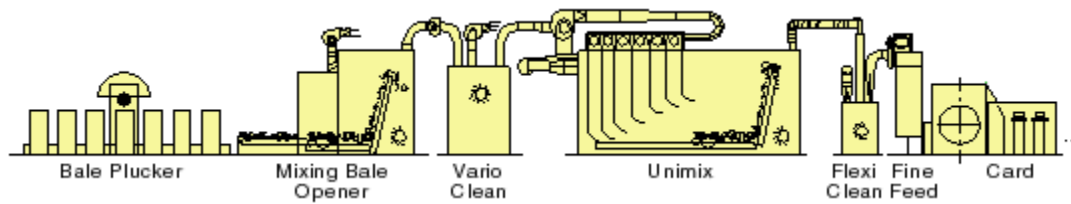


Fig.16

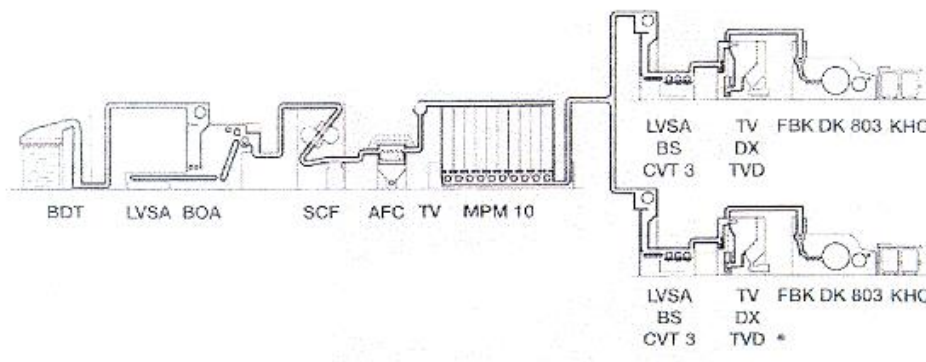
- Blow room machinery lay out should be designed in such a way that there should be minimum number of bends, and there should not be sharp bends to avoid fibre entanglements.
- Some of modern blow room line from a few companies are shown in Fig.17. However, sometime it may be desirable to go for combination of machines from different manufacturers.



Rieter Blow Room Line



LMW Blow Room Line



Trutzchler Blow Room Line

Fig.17

CARDING

In the yarn manufacturing process, carding comes after opening and cleaning of fibres at blowroom. Carding process is considered so important that carding is often called “the heart of spinning”.

OBJECTIVES OF CARDING

- Individualization of fibres

Carding is done primarily to individualize fibres. Blow-room machines open fibers in the form of flocks and a card does the finishing operation of opening by individualizing them. In doing so, the process has to make sure that minimum fibre damaged is caused. This is essential for subsequent drafting and attenuation required in spinning a yarn.

- Elimination of Impurities

The degree of cleaning of card is 80-90%. After carding, the material contains 0.05-0.3 % of trash and other foreign matters. Major cleaning is achieved in licker-in region in a card.

- Elimination of Dust

Dust removal requires significant fibre/metal and fibre/fibre friction; since, both are available in carding, it is a good dust eliminating point.

- Reduction in Neps

Number of neps in fibres increases in the blow-room. In carding, neps are drastically reduced as shown in Fig.C1. This can be attributed largely to the un-entanglement of neps rather than removal of neps during carding action.

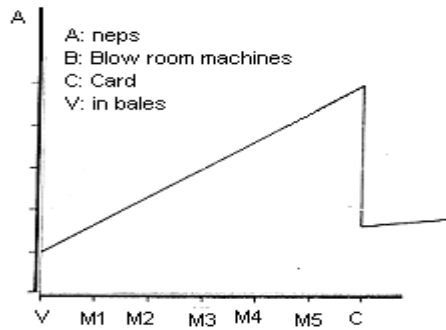


Fig. C1

- Fibre Blending

Although there is a repeated rotation of fibres in the card cylinder before it is removed by the doffer, the time spent is very small. So, there is not much longitudinal blending in carding. However, sufficient transverse blending takes place when web is condensed in to a sliver. The longitudinal blending action of a roller and clearer card used in woolen and worsted spinning is however much higher.

- Sliver Formation

Card forms a bulky sliver of overlapping and partially aligned fibres. The linear density of card sliver in short staple spinning is usually 4-5.5 ktex. In some cases, the range of linear density may be from 3-6 ktex.

Additional Objective of woolen card

Woolen card delivers the full width web of fibres into narrow round twist-less threads ready for direct spinning in ring frame.

Additional objective of Jute Card

In bast fibres, such as jute, fibres are not completely separated but arrive in spinning mills in the form of bundles. Cards split fibre bundles into finer forms, so that the drafting is easy and finer yarn can be produced.

BASIC DESIGN AND OPERATING PRINCIPLE OF A CARD

Here, a flat card used in short staple spinning system is discussed. Such a card is shown in Fig.C2.

Fibres are partially cleaned and opened into flocks in the Blow room and then delivered in to a card either in the form of a lap or evenly compressed batt of about 500-900 ktex via chute. In case lap is feed into a card, then, lap has to be unrolled at the back of the card. A feed plate and feed roller (4) push the sheet of fibres slowly into the licker-in (5) while maintaining clamping.

Fibres are intensively opened into very small flocks by the licker-in wire points. Trashes are separated due to the action of mote knives and grid under the licker in (6).

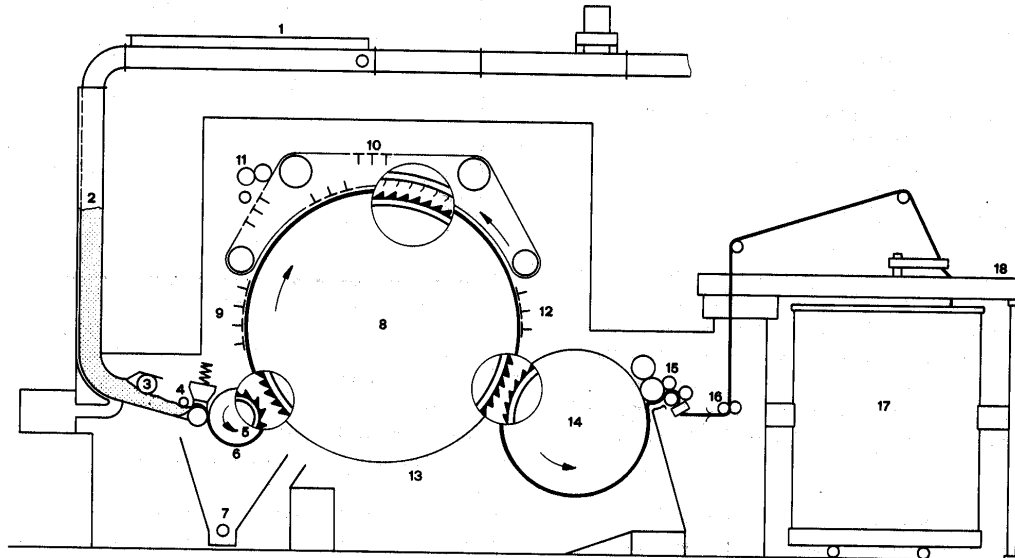


Fig.C2

Fibre flocks are transferred to the cylinder (8) by a point to back stripping action between licker-in and cylinder wires. Main carding action takes place between cylinder and flats (10) and flocks are opened up into individual fibre in this carding action. Sizable portions of neps are also opened up. The flat may rotate either in the same (forward) or in the opposite (backward) direction to that of the cylinder. The flat comprises 80-116 individual carding bars combined in to a band and moves in an endless path. Some 30-46 flats remain in the working position with the cylinder. Short fibres, neps and trash tend to remain with the flat wire and are removed by flat doffing comb as flat strips. The

underside of the cylinder is enclosed with cover plates (13). In most modern cards, fixed carding bars (9&12) are provided before and after the main carding zone to have better carding action.

The doffer (14) combines the fibres carried by the cylinder and forms a web. Due to lower surface speed of the doffer compared to the cylinder, a sufficiently thick web of fibres is formed. The web has cohesion to stand by itself without any support.

The web is released from the doffer either by a doffing comb (old cards) or by doffing roller (modern cards). Crushing rollers (15) are usually found after doffing roller to pulverize any remaining trash before the web is condensed and compressed by the calendar rollers (16) and deposited in to the can (17).

TANDEM CARD

In this case, two individual cards are joined together to make up a unit. The doffer of the first card feeds the material to the licker-in of the 2nd card. Carding quality is better. However, the cost of such machines is high and maintenance is difficult. Tandem card is shown in Fig.C3

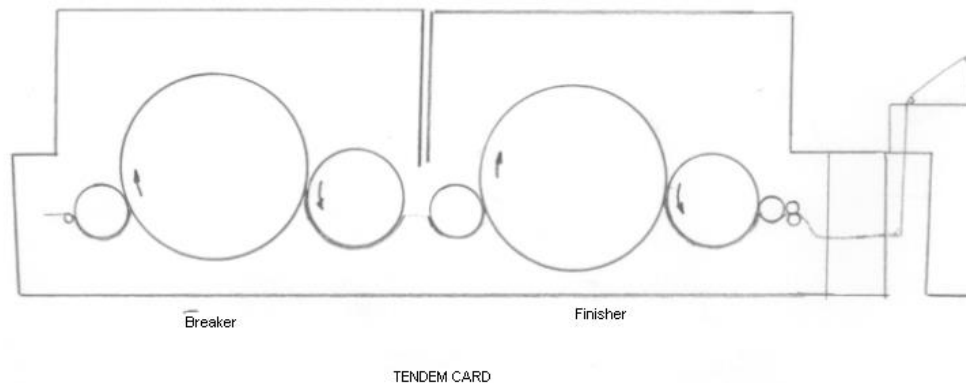


Fig.3

CARD CLOTHING ARRANGEMENTS AND FIBRE TRANSFER

Analysis of Disposition

Wire points between two surfaces under action in a carding machine are disposed in the following two forms:

- Carding Disposition(Point to Point)

- Doffing or Stripping Disposition(Point to Back)

Carding Disposition (Point to Point)

The teeth are oppositely directed. This is found between cylinder and flats and also between cylinder and doffer. Here, fibres are drawn apart, separated and aligned. Fig.C4 shows such a disposition between cylinder and flats.

Effectiveness depends upon:

1. Relative direction of movement of the working surfaces.
2. Relative Surface Speeds
3. Point density and angle of wires
4. Setting (gap between the wires of two surfaces)

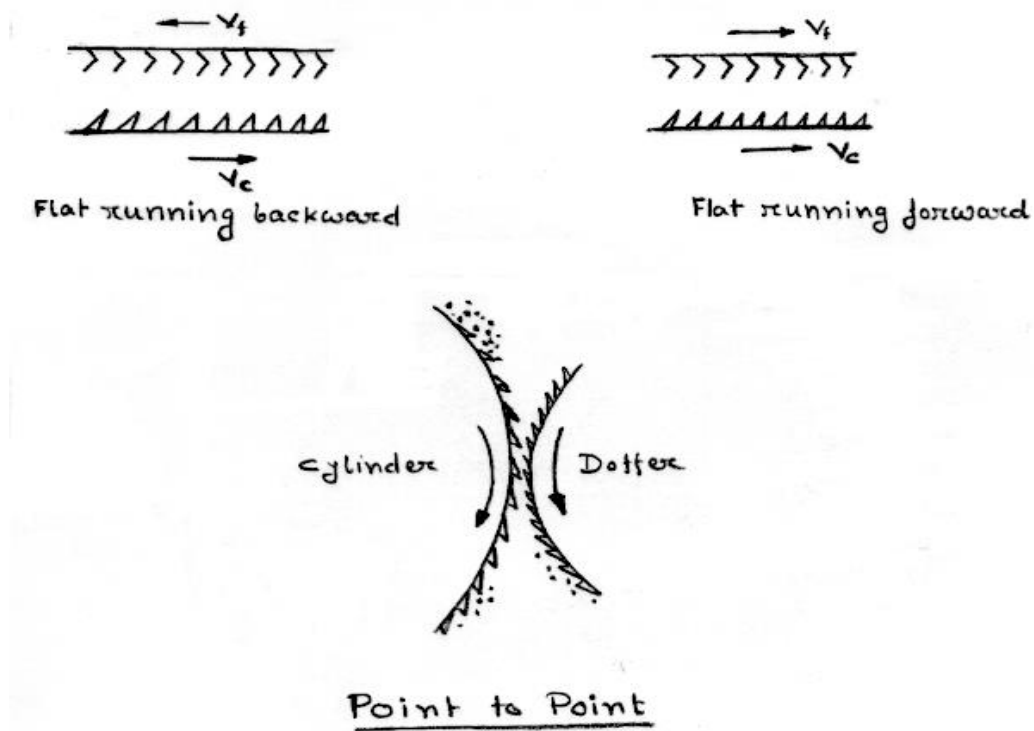


Fig.C4

Doffing or Stripping (Point to Back) Disposition

This is shown in Fig.C5.

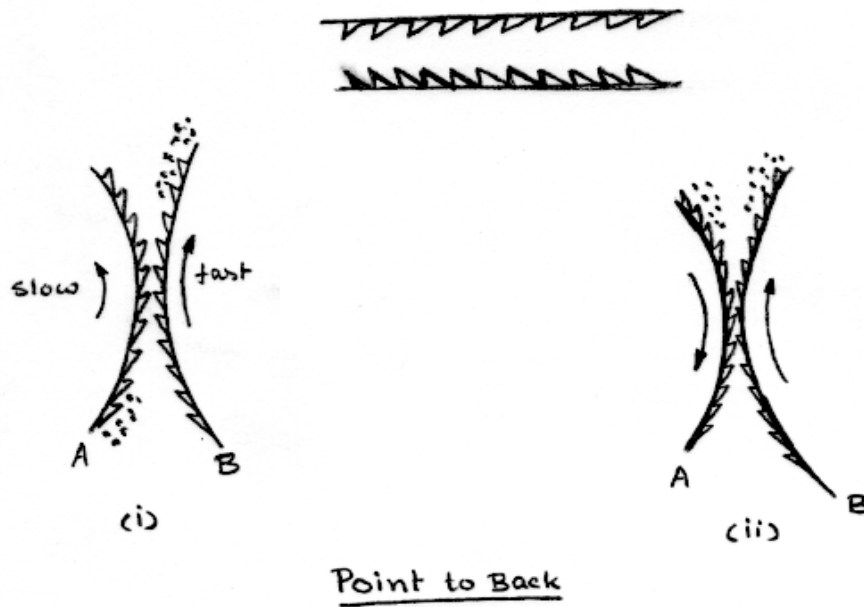


Fig.C5

This action is used to strip all fibres from one surface to another, normally using a close setting. Two examples are Fig C5. Surface A is stripped by surface B. Surface speed of “B” has to be more than the surface speed of “A” if direction of rotation is as shown in (i). Otherwise, direction of rotation should be according to Fig. (ii).

The following are important influencing factors for fibre transfer:

1. Relative direction of movement
2. Relative Surface Speed
3. Point density and angle
4. Setting(very important)

This disposition is found between licker-in and cylinder.

Forces on Fibre during interaction between wires

In Caring Disposition (Point to Point)

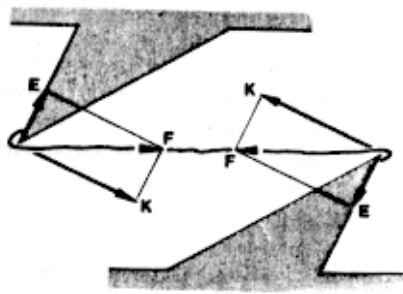


Fig.C6

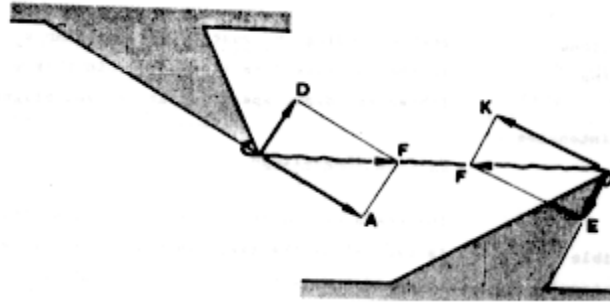


Fig C7

As shown in Fig C6, the tensile force **F** acts in the axial direction due to drag from both sides. **F** can be resolved in-to **E** and **K**, where **E** is the component trying to retain the fibre in to the clothing and **K** is transfer (or carding) component which helps the fibres to pass to the other wire. The relative intensities of these force components in each surface decide fibre transfer between points.

In Doffing Disposition(Point to Back)

As shown in Fig C7, the tensile force **F** acts in axial direction. **F** can be resolved into component **D** and **A**, where **D** presses the fibre into the clothing and **A** helps in stripping. Role of **K** and **E** are same as in Fig.C5.

INTERACTION AND FIBRE TRANSFER

Interaction and Fibre Transfer between Licker-in and Cylinder:

Fibres are transferred to the main cylinder from Licker-in by point to back (stripping) action and the draft between licker-in and cylinder is around 2. It helps for a longitudinal order of fibres in cylinder. This depends on the surface speed ratio between the cylinder and the licker-in. This ratio should be around 1:2 for cards with one licker-in. In order to have good stripping by the cylinder, the following factors are important

- The metallic wire of the licker-in must be coarser and less dense than that of cylinder.
- The surface speed of the cylinder must be faster than that of licker-in.
- The setting gap between the licker-in and the cylinder should be close, but, should not be too close so that the fibres are not pressed deeply in to the cylinder wire inter-space.

Interaction and fibre transfer between Cylinder and Flats:

If all other things remain unchanged, fibre transfer from cylinder to flat and flat to cylinder depends on chance. Thus, carding will obviously be more if, more fibre transfer between cylinder and flat wire points takes place. Cylinder wires comb fibres under control of flats; as cylinder surface speed is much faster compared to almost stationary flats. Carding is therefore better, if the following conditions are satisfied:

- Wire points are sharp
- Fibres are held by flat wires more firmly
- Tufts are distributed more uniformly and tuft size is small.

Interaction and fibre transfer between Doffer from Cylinder

The following factors affect fibre transfer from cylinder to doffer:

- *Tooth Density:* Increase tooth density in doffer helps transfer from cylinder to doffer. However, there is an upper limit in metallic clothing for raising tooth density.
- *Tooth Angle:* Greater angle of doffer wire points form a higher drawing in component **E**, thereby helps doffing from cylinder.
- *Tooth Height:* More height in doffer wire helps having a higher transfer factor.
- *Clean Wire:* Maintaining doffer wire points clean and receptive by continuously withdrawing web results in better fibre transfer.
- *Setting:* Very narrow setting between the cylinder and doffer assists transfer of fibre by air circulation in the convergent space between cylinder and doffer. For example, changing setting from 7"/1000 to 3"/1000, may result in an increase of transfer by almost 100%.
- *Speed relationship:* Low doffer speed means low number of doffer points are presented in a given time and hence, low transfer and vice versa.

In spite of all these factors, fibre transfer to doffer is very less because, fibres while passing through the main carding zone are pushed by the flats deep into the gaps between the cylinder wires. Therefore, fibres are not likely to be transferred to the doffer easily.

The transfer factor is only 0.2-0.25. This means that fibres on an average rotate 4-5 times around the cylinder before being doffed by the doffer.

Why doffing by doffer is through Point to Point rather than Point to Back?

It appears logical to arrange the clothings of the cylinder and doffer in doffing disposition (Point to Back). However, they are arranged in carding (Point to Point) disposition. This is essential, because, fibres get randomly arranged in the doffer which provides necessary cohesiveness required in the web. Doffing (point to back) disposition would make the fibres aligned and reduce the cohesiveness and so the strength of the web would not be sufficient for a stable operation. Moreover, the point to point interaction also provides another combing action by cylinder wires as cylinder wire points rack through the fibres held by the doffer wire points. This may result in better carding and fibre separation. However, the disadvantages of this arrangement are:

1. Parallel arrangement of fibres achieved in carding cylinder is not retained.
2. It leads to the formation of hooks.
3. Poor efficiency of fibre transfer (0.2-0.3), and consequently more load on the cylinder clothing.

THEORY OF CARDING ACTION BETWEEN CYLINDER AND FLATS

Cylinder and the flats together form the main carding zone. Flats always have flexible clothing. In the working zone, there are 30-46 flats depending upon the design. Although, mostly in conventional cards, flats move in the forward direction (same as cylinder), in some of the modern high production cards, movement is reversed.

Action in the main carding zone

The major effects seen in the carding zone can be summarized as follows:

- Opening into the individual fibres
- Elimination of remaining impurities
- Untangling of neps
- Removal of some short fibres.

Short fibres, once get loaded in flats, are not returned to the cylinder and therefore, are removed as flat strip. However, proportion of short fibres in flat strip is not very high, as short fibre transfer to flat takes place only in the first few flats. A card eliminates 1-2 %

flat strip. Approximately 50% are short fibres. If an increase in flat strip is attempted by wide setting of the front plate, it is seen that additional flat strip contains mostly long fibres.

As regards the neps, research studies indicate that 60% of the neps are disentangled in the carding zone. Out of the remaining 40%, the distribution of neps is as follows:

- 30-33 % will pass into the sliver
- 5-6 % will be removed with the flat strip, and
- 2-4 % in wastes, other than flat strips.

If fibre throughput through the cylinder is more, some of the fibre bundles do not get transferred into the first few flats; the opening becomes difficult. It then will be rolled up between the working surfaces and may lead to formation of more neps. So, total nep reduction depends upon the net effect of disentanglement of neps and formation of new neps.

The overall carding effect between flats and cylinder depends on:

- Sharpness of Clothing
- Tooth density of clothing
- Settings between Cylinder and Clothing
- Pre-Opening in licker-in and pre- carding fixed elements.
- Transfer rate to doffer
- Relative speed between the cylinder and flats

The action of cylinder wire (combing) on fibres while fibres are held by the flat is shown in the Fig C8. While fibres held by the flats are combed by the cylinder wire, the same fibre is also transferred to the cylinder after a number of combing actions. The fibre gets reversed a number of times during its movement through the carding zone.

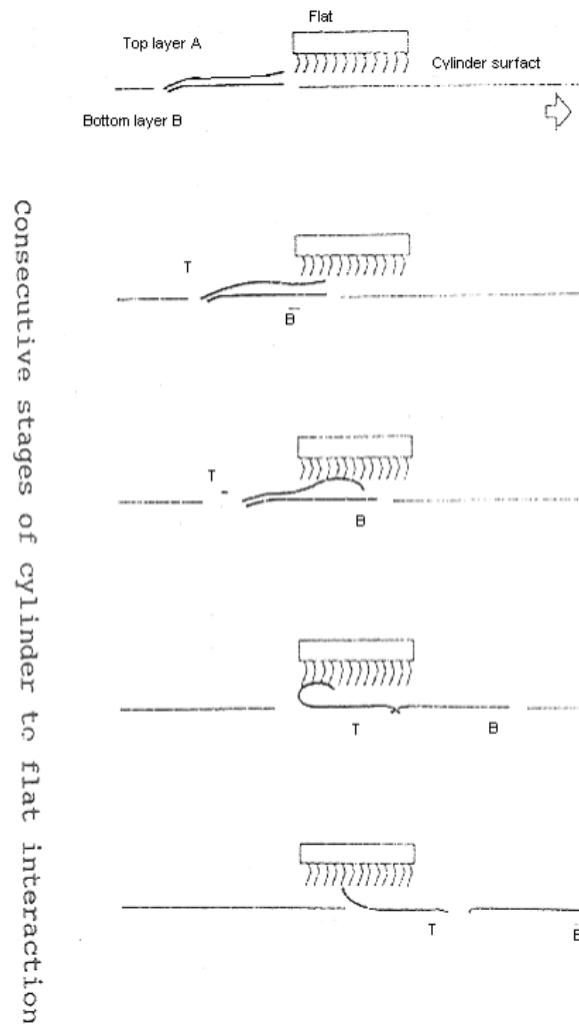
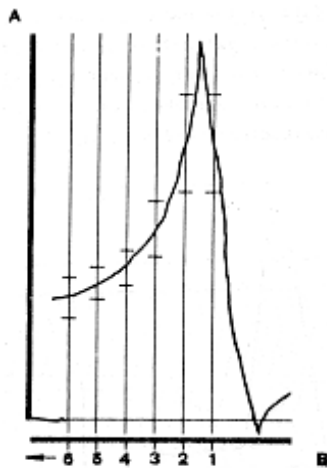


Fig C8

ADVANTAGES AND DISADVANTAGES OF FORWARD AND REVERSE MOVEMENT OF FLATS

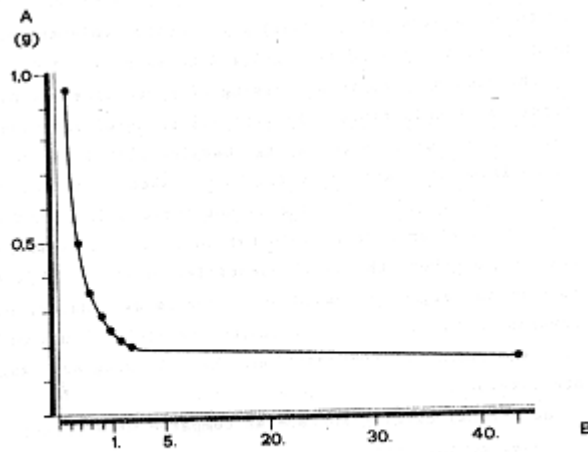
When a flat moves into the working zone from the licker-in end, it gets loaded with fibres. A flat loaded with fibres can not properly snatch fibres from cylinder. Therefore, carding effect is gradually reduced as it moves forward. This is shown in Fig.C9. This clearly points out that actual carding takes place only in the first few flats. In the case of reverse movement of flats, since flats are filled up when they reach towards licker-in side, their receiving capacity is lost and so opening effect is low, but sufficient enough for elimination of dirt, particularly when fixed carding segments are provided above the licker-in. So, as the cylinder carries the material for cleaning into the flats, the flats take

up the dirt, but instead of transporting dirt and short fibres towards the doffer, take them up out of the carding zone to be eliminated as flat strip.



A: Carding effect
B: number of the flat from the entry point

Fig C9



for Flat moving in reverse direction
Dirt take up from the entry point; A: flat loading; B: number of flat bar in the material flow direction

Fig C10

Fig C10 shows how dirt is removed by flats from the material entry point. Thus, the reverse movement of flats has technological advantage. However, removal of flat stripping is easier in forward movement of flat.

STUDY OF THE IMPORTANT WORKING REGIONS OF CARDING MACHINE WITH SPECIAL REFERENCE TO MODERN HIGH PRODUCTION CARDS

FEEDING DEVICE:

The objective of the feeding device is to clamp the fibre batt over the full width and present it at a fixed rate to the licker-in for gentle opening.

A conventional feeding device is shown in Fig. C11.

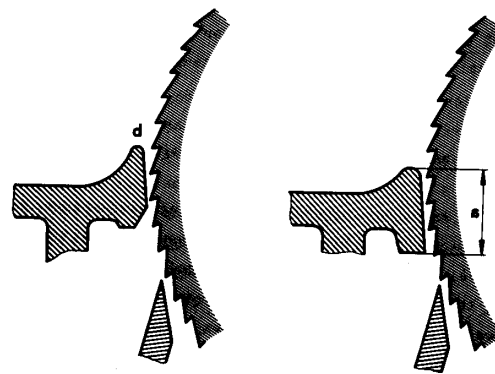
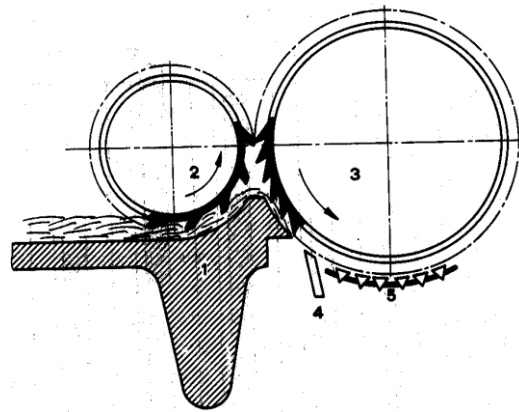


Fig C11

1 is feed plate and 2 is feed roller which is pressed against the feed plate. The feed plate is basically an extension of the feed table. The guide surface length (a) and nose (b) of the feed plate play important roles in opening.

A sharp nose holds the fibre strongly, thereby helps intensive but less gentle opening. Round nose results poor retention and so bad opening; licker-in may tear out lumps of fibres.

The length of guide surface has influence on waste %. A short guide surface leads to more waste removal by mote knife. Long surface results in fibre pressed against the licker-in and results in low waste (also, low separation of trash). The length is therefore dependent on fibre length (within a broad range). Feed roller diameter is usually 80-100

mm. Teeth direction is kept against the material flow for better retention. Some machines do have feed rollers without teeth, but with flutes.

New Developments

As shown in the conventional feed, the batt has a tendency to move in the direction of the feed roller and thereby undergoes a sharp bend in the direction of rotation of licker-in. This does not contribute to the gentleness of opening. A new system provided in some modern cards, the feed cylinder is located below the spring loaded plate (Fig C12).

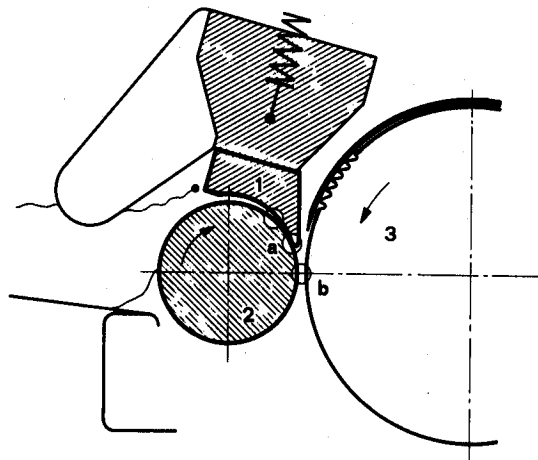


Fig C12

The feed batt runs downwards without any diversion, thereby helps gentle opening in licker-in.

In conventional system, feed plate to licker-in setting is adjusted, whereas, in the new system, setting point is b/a. "a" and "b" are shown in the figure C12.

LICKER-IN

Licker-in is a cast roller with saw toothed clothing fixed on it. Beneath the licker-in there is an enclosure of grid elements or carding segment. Mote knives are also fixed to help separation of trash. The major functions of licker-in are:

1. Open material into very small flocks
2. To clean fibres by separating trash particles

Opening

In modern carding machines, almost 50-70 % of material is transferred into cylinder by licker-in in the form of very small flocks and rest 50-30 % as individual fibres. As such, very intensive opening is performed by the licker-in. The following parameters are common in licker-in for modern carding machines:

Diameter: 250 mm

RPM: 1000

Points/Second presented to incoming batt: 600000

For conventional cards with cylinder speed of 168 RPM, the best licker-in speed is between 420-600 RPM. The circumferential speed of licker-in is around 13-15 m/sec and draft between feed roller and licker-in is more than 1000. It shows clearly fibres get deteriorated at this opening point. Therefore, higher speed gives a better cleaning, however, at the cost of rather higher fibre damage and possibly more loss as short fibres get eliminated. Moreover, with the speed, stress on the fibre also increases. In the region of licker-in fine fibres and most particularly, the long synthetic fibres require more gentle treatment. The degree of cleaning, opening and fibre damage depend on:

- Thickness of batt
- Density of batt (which depends on pre opening)
- Degree of orientation of feed fibres.
- Material throughput speed
- Speed of the licker-in
- Licker-in clothing
- Type of feed
- Settings

Separation of Trash

The conventional cleaning system in licker-in region consists of 1-2 mote knives and a grid. This is shown in Fig. C13. One half of grid is made of slotted sheet (b) and other half of perforated sheet (c). Most of the foreign matters get eliminated exclusively by scrapping off on the mote knives. The grid sheet tends to serve as fibre guide. It back ejected fibres.

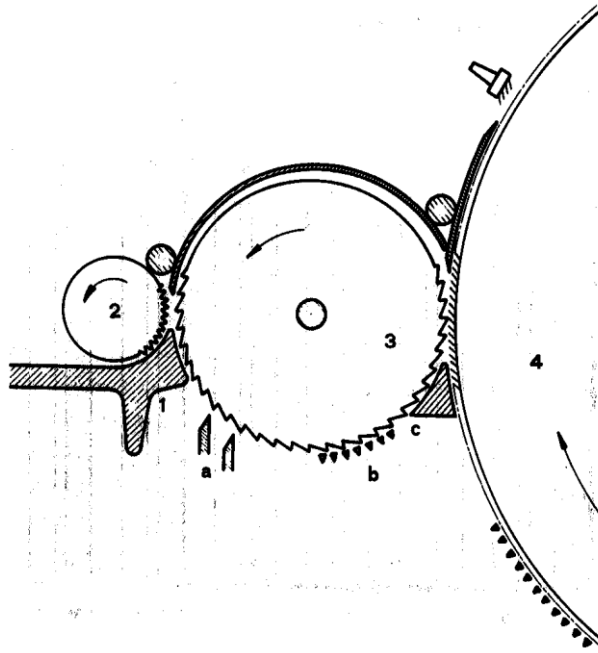


Fig C13

In high performance cards, no grid bars are provided. Instead, carding segments are used. This is necessary to take care of the high volume of material passing through the machine in unit time. As an example, in Rieter Card, flocks are first guided over a mote knife (Fig C14), then over carding plates (b), then again over mote knife and then again over carding plates.

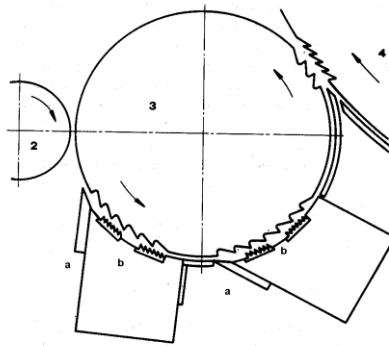


Fig C14

Multiple Lickers-in

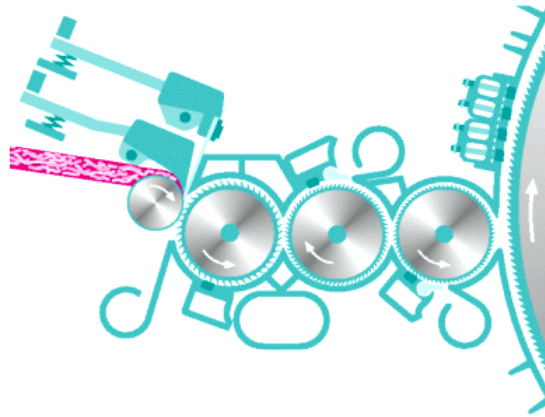


Fig C15

Several manufacturers of modern high production cards incorporate multiple licker-in in carding machines. The clothing arrangement is point to back, relative to each other and speeds are progressively increased, for example from 600 RPM (1st licker-in) via 1200 RPM to 1800 RPM (3rd licker-in). Due to such high speeds, trashes are eliminated due to centrifugal force. Moreover, since speeds are progressively increased and material is not being plucked at very high speed by the 1st cylinder from the feed roller, opening is gentle. Since, modern high production cards process large quantity of material (up to 100 kg/hr), thorough opening in licker-in is very essential in order to avoid uncarded material passing to the sliver.

CARDING CYLINDER

Cylinder is mostly made of cast iron or steel and covered with card clothing. Diameter is usually 1280-1300 mm and speeds vary from 250-600 RPM. Some manufacturers claim reaching cylinder speed up to 750 RPM in their recent models. Cylinder is mostly supported in roller bearings. Precision of cylinder design is one of the major challenges in designing and manufacturing of modern high production cards.

Beneath the cylinder, either there is a grid with traverse slots or a closed sheet. Above the licker-in and also above the doffer, there are protective casing. One of these protective sheets near the flats (known as front plate) is specially formed as a knife blade. Flat strip can be regulated by adjusting the distance between the cylinder and the front plate. A closer setting results in a reduction of flat strips. The reason for decrease in the amount of

flat strip as the lip of the front plate is moved nearer the surface of the cylinder is that this intensifies the current of air being carried under the plate by the quickly moving cylinder. It helps fibre transfer from flats to cylinder. Air current does not remove the fibres, but assists the cylinder to rob fibres from the flats.

FLATS

Flat bars are made of cast iron. But recently developed cards have aluminum bar flats. Each bar is approximately 32-35 mm wide. Bars are given ribbed form (T shape) in order to prevent longitudinal bending (Fig C16)

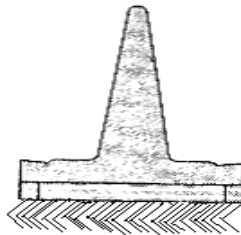


Fig C16

The arrangement of wire points towards the material flow direction is narrower as shown in Fig. C17. This is required so that fibres are not pushed along, but can pass underneath the wires points and have progressive opening.

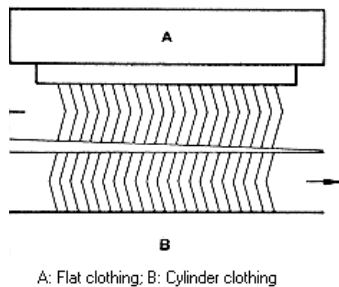


Fig. C17

ADDITIONAL CARDING SEGMENTS

The opening effect in carding can be correlated to the number of wire points per fibre (number of points presented in a unit time / number of fibre feed in the same time). In licker-in, this ratio is approximately 0.3 (three fibres per point) and in the main cylinder, it is about 10-15. With the ever increase in production rate of modern high speed cards (kg/hour), this ratio and so the carding effect tends to decrease, unless:

- Finer Card clothing is used(more points per unit area)

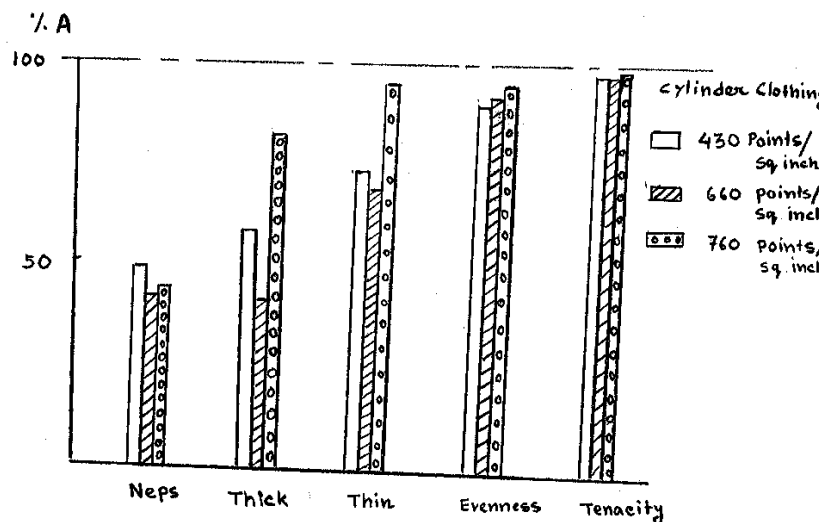
- Higher roller and cylinder speeds are used.
- More carding surfaces are created.

Clothing cannot be made very fine particularly for coarse fibres; since while processing waste fibres, clothing gets loaded very fast. At high throughput rate, loading of clothing is till more serious.

There is also a limit to increase cylinder speed. Speeds of up to 750 RPM is reached in recent models. However, there may be fibre damages at very high speeds, as the force exerted on fibres is very high.

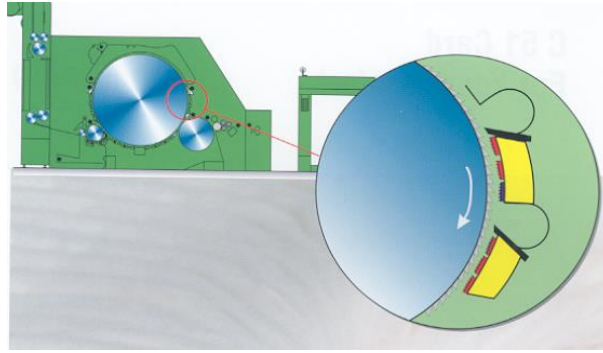
Thus, the best way to increase throughput without sacrificing carding effect is to have additional carding points. Thus, more licker-in rollers are used to open the fibre almost to an individual fibre level before transferring it to cylinder and additional carding plates are provided in all modern machines. The carding segments ensure further opening, thinning out and, primarily spreading out and thereby improve distribution of flocks over the total surface area. These additional carding plates and also multiple licker-in thereby make closer settings and high speeds possible without much fibre damage.

Even, carding segments above the doffer (after the main carding zone) help fibre orientation and transfer to doffer. Fig C18 shows research results on the effect of carding bars following the flats. Fig C19 shows the arrangement of carding bars before and after the flats.



Improvement in yarn properties with the use of carding bars following the flats:

Fig C18



Carding bars at feed and at delivery (Rieter C51 Card)

Fig C19

DOFFER

The doffer is mostly made of cast iron and fitted with metallic clothing. Diameter is 500-700 mm. Doffer runs at a speed of 40-100 RPM. Surface speed is 500-700 m/min

DETACHING AND SLIVER FORMATION

On conventional cards, web is doffed from the doffer by an oscillating comb. It oscillates up to 2500 strokes per minutes. In all high production cards, it is replaced by a roller.

Immediately after the detaching roller, almost all high production cards have two smooth steel rollers, one above the other. They are usually loaded with a pressure of 15 N/m. As the web is passed through the polished rollers, any more dirt particles that remain with the fibres get crushed. These crushed particles further fall off the web. If cotton is sticky, then processing becomes difficult with crushing rollers. Too high a crushing pressure, particularly for very clean cotton, results in fibre damage.

In conventional cards and also in modern cards with roller doffing, web is condensed by a funnel shaped condenser, just before the calendar roller. Up to the condenser, it runs a distance of 30-50 cm in a freely suspended form in a wedge shape. However, in high production modern cards, web if exposed falls apart due to high speed and so web must be condensed immediately after the detaching rollers. This can be done in various ways, such as:

- Several transversely disposed guide rollers
- Traverse sliver condenser, giving central delivery or single circulating condenser giving side delivery.

COILING IN CANS

The slivers are coiled in cans for storage and transportation. Coiling is done cycloidally. Can diameters are in the range of 600-1200 mm. Heights: 1000-1220 mm. Cans used subsequently in open end machines are smaller: 350-400mm diameter. Most of the modern high production cards have automatic can changing mechanism.

VARIOUS TYPES OF CARD CLOTHING

The term card clothing is used to describe the large number of pins covering the roller/cylinder surfaces. There are three groups of clothing:

- Flexible clothing
- Semi flexible clothing
- Metallic clothing

The type of card clothing required depends on many factors such as:

- Design of cylinder and rollers
- Speed of cylinder and rollers
- Material throughput
- Fibre type and characteristics
- Quality requirements and price of clothing

FLEXIBLE CLOTHING

Flexible Clothing is mostly found in woolen cards. In high production short staple cards, this type of clothing is found only in flats. Mostly, flexible card clothing is made in the form of fillet, which is a narrow continuous length of clothing helically wound around the roller. Wires are fixed on the foundation to form the fillet. The cross-section of wires used is shown in Fig C20.

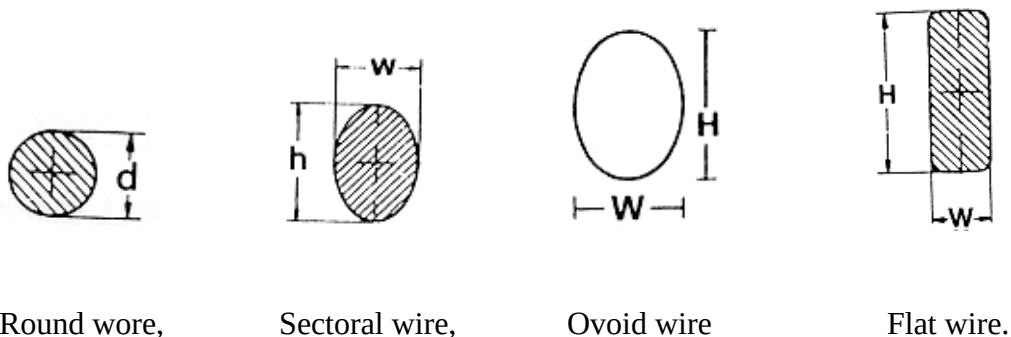


Fig C20

Sectoral and ovoid wires are similar but, ovoid wires have a difference of seven gauges between the two cross sectional dimensions(H & W), whereas sectoral wire has a difference of four gauges.

The basic reason for the use of sectoral and ovoid wire is that, by increasing the lengthwise dimensions of the cross section, more strength is given in the carding direction of the wire and the tooth is more resistant to bending. The number of teeth around the circumference of the roller is reduced. Flat cross sectional wire is commonly used for fancy roller in woolen card, since due to the flicking action of the individual teeth, more strength is required in one direction and in the other direction cross section must be small to help the wire enter in the gap between cylinder wires.

The basic fillet foundation is made by gluing together layers of cotton cloth. Generally, the number of layers may vary from four to ten. In order to increase the strength of the fillet, middle layer is normally made of linen. If the teeth are not held firmly, they ultimately become loose and ineffective. On the other hand, if the teeth are too firmly held, then their flexibility is lost. Moreover, more stress will be put on the teeth and it may eventually break at the surface of the foundation. Vulcanized rubber, wool felt etc. are also used on the top layer in many fillets. In most of modern cards, rubber-cushion (thick cellular rubber) foundation is used which increases the stability of the teeth and enables them to withstand greater amount of stress. Such foundation prevents oil and grease from soaking into the woven base foundation.

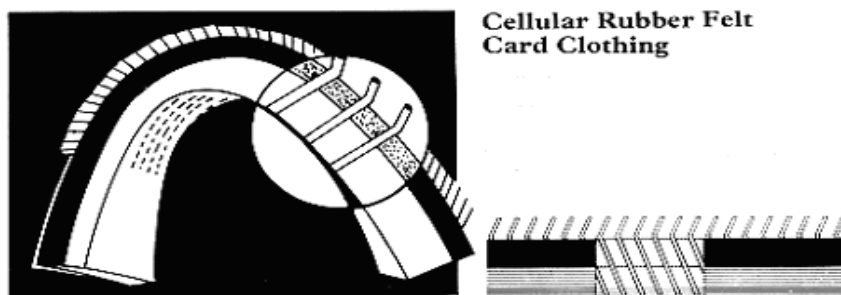


Fig C 21

Wire Geometry

The flexible wire with a knee is shown in Fig. C22.

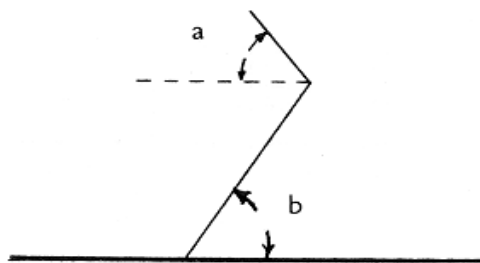


Fig C22

The angle 'a' determines the card clothing's ability to catch fibres. It also determines the ease with which the fibres can be stripped from the teeth. The angle thus depends on the position and function of the roller on which it is mounted.

The angle 'b', called back prick, is important in regards to the stability of the teeth.

The requirement of the knee can be explained with the Fig. C23.

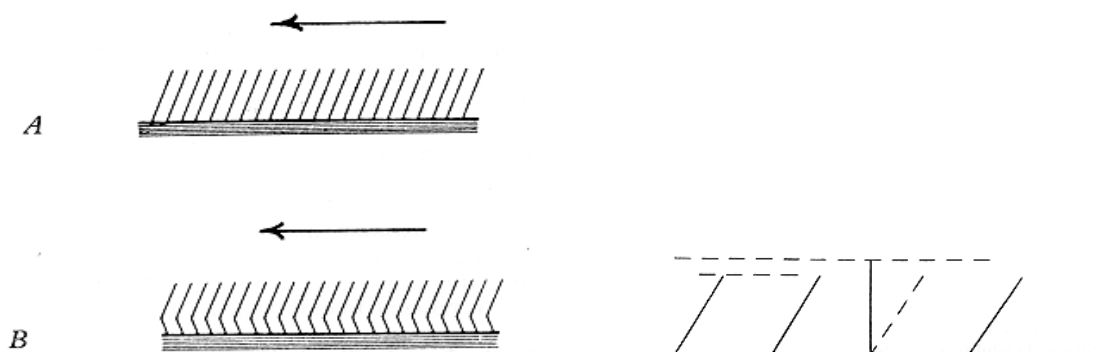


Fig C23

If straight teeth as in (a) are subjected to a carding action in the direction shown, the teeth will be continuously forced to bend back until they either pointed in the opposite direction or eventually break off just above the foundation.

In (b), the lower section of each tooth is bent backwards under strain, they continue to lean in their original direction and suffer less strain. Moreover, the points of the teeth remain facing in the correct direction.

A further consideration is that a tooth of the card clothing at (A) is bent back, the point of travel through an arc and overall height of the tooth is consequently increased. This can impose restriction on fine settings. In case of wire having a knee ('B'), the point would be forced down rather than up.

SEMI RIGID CLOTHING

These are similar in structure to flexible type; however, the backings are less elastic than flexible clothing. Flat wires are not formed with a knee, but round wires may have one. They do not choke with fibres like flexible clothing. However, the disadvantage is that, they are less capable of yielding when subjected to a bending load. They are used in flats only in cotton cards. The modern flat top is semi-rigid type, having flexible foundation and sectoral wire. The points are well backed off and side-ground to give the necessary degree of fineness.

RIGID METALLIC CLOTHING

This is manufactured in two forms: Inserted pin and rigid metallic wire.

Inserted Pin

In this type, pins are set in a rigid foundation such as metal or wood. Such types are found in Jute and Flex cards and also may be on early rollers of a woolen card. Pin concentration (pin/sq cm) is usually within the following limits:

Jute breaker card: 0.3 - 1.25

Jute finisher card: 0.8 - 1.4

Flex breaker card: 5.6 - 9

Flax finisher card: 5.6 - 9

Rigid metallic wire

This type of clothing is extensively used in licker-in and cylinder of cotton cards and is increasingly becoming popular for worsted and semi-worsted cards. For such cards, wool regain should not be more than 25% and fat content should be less than 0.6 %, as within these limitations, wool fibre breakage is not significantly high.

The development and use of rigid metallic clothing is the key to success of high speed high production cards, as flexible wires can not withstand high strain imposed when the machine runs faster along with high throughput rate.

The wire is made in long continuous lengths with a rectangular cross-sectional base from the base of which, project the hardened teeth. Wire is hardened during manufacturing by

passing through flame and a quenching bath. A high degree of uniformity in hardening is required. Since the base has to be wound on a roller, this portion has to remain relatively soft and pliable. The wire is wound on the roller or cylinder in spiral form. High carbon alloy steel is used to manufacture a cylinder wire.

In order to mount the wire, (Fig.C24), the normal profiles for licker-in (Fig “a”) or for cylinder (Fig “b”) are either pressed into the grooves of licker-in or are simply wound under high tension onto a plain cylinder. 'c' and 'd' show two more arrangements used in licker-in without groove (Chained and locked). Interlocking wire points are almost unbreakable and there is no threat to breakage in the case of a foreign body entering the machine.

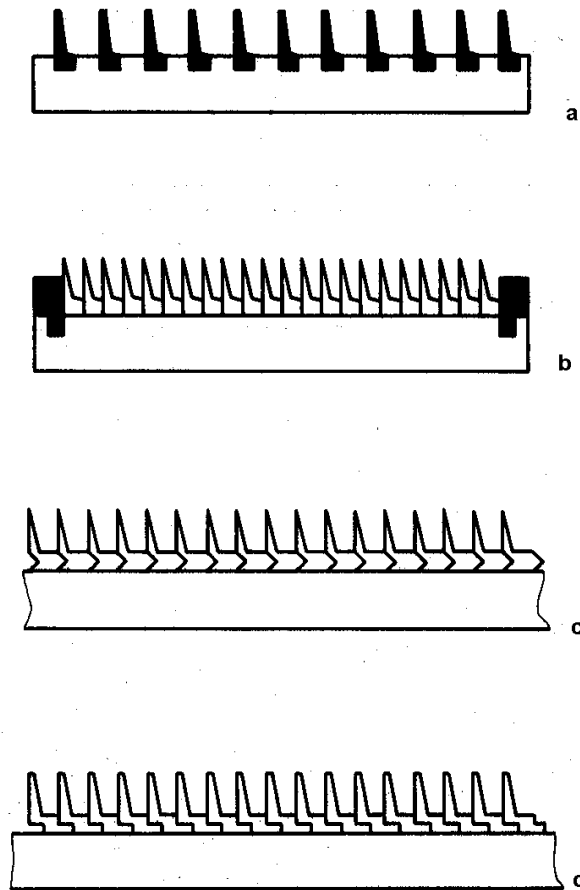


Fig C24

The specifications and geometry of the teeth are presented in Fig. C25.

a_1 : Base width
 a_2 : Tooth thickness at the root
 a_3 : Tooth thickness at the tip
 h_1 : Overall height of the tooth
 h_2 : Height of the base
 h_3 : Depth of the tooth
 T : Tooth pitch (when the wire is stretched out)
 α : Carding angle (or face angle)
 β : Tooth apex angle
 γ : Trailing angle

Angles are measured when they are stretched out.

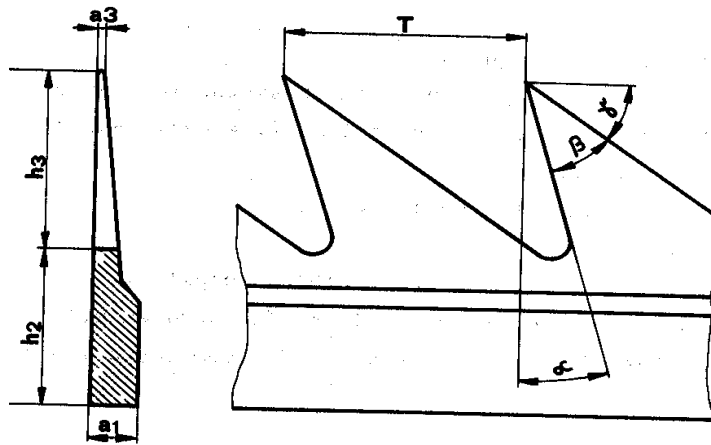


Fig. C25

SOME IMPORTANT PARAMETERS IN CARD CLOTHING

Point Density

This is the number of points per square area. In general, high point density gives a better carding effect. However, if point density is above the optimum, then loading of clothing would take place and carding effect would be deteriorated. Point density largely depends on fibre character, the most important of which is fibre fineness. Coarse fibres require low density. Moreover, point density at different positions (licker-in, cylinder, doffer etc.) must be relatively maintained. Point density is also related to the roller speed and material throughput; because, number of points presented to the number of fibres in a

given time is a very important factor that determines the efficiency of carding. Point density also depends on the total available carding surface in the machine.

Calculation of Point Density:

$$\text{Points /sq. cm} = \frac{100}{\text{BaseWidth(mm)} \times \text{Pitch(mm)}}$$

Height of Clothing

If angles were to remain the same, then a shorter tooth gives a low pitch, thereby density can be increased. Moreover, a short tooth reduces choking and thereby better carding over the total surface can be achieved. Thus, on the cylinder, tooth height is kept short, usually, 2mm-3.8 mm. If height is too short, then fibre control will be less; at the same time, if height is more, then fibre transfer to doffer will be less and recycling will take place resulting in neps.

Angle

Referring to Fig. C26, the carding angle (α) is the most important angle of the tooth. The aggressiveness of the clothing and fibre retaining power are determined by this. The normal range is usually kept as follows:

Licker-in	+ 5 ⁰ to -10 ⁰
Cylinder	+12 ⁰ to +27 ⁰
Doffer	+20 ⁰ to +40 ⁰

Negative angle is used in licker-in for processing man-made fibres, since cleaning is not the objective. Even in cylinder, for man made fibres, low angle is used.

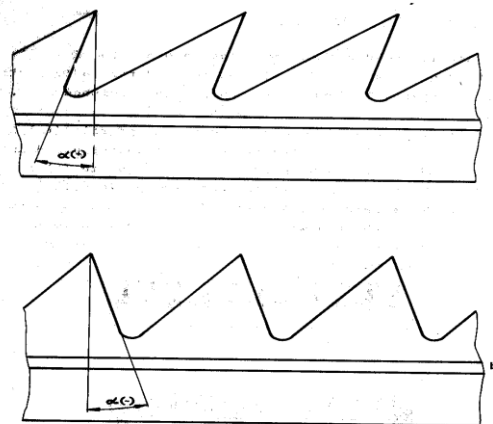


Fig. C26

Trailing angle

A lower trailing angle reduces the fibre loading, but higher angle helps better penetration. Angle between the two extremes should be selected.

The tooth point

For optimum operation, the point should not have a needle form but, should have a land as shown in Fig. C27. In order to provide retaining power, the land should terminate in a sharp edge. This edge should be maintained by necessary grinding from time to time. However, too much of grinding is not desired, otherwise land (b) becomes too large for satisfactory carding.

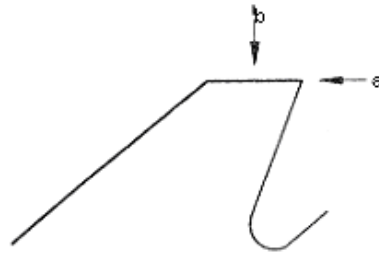


Fig. C27

Cut to point tooth

Most of the recent cylinder wires have the smallest land or cut-to-point tooth. Sharp point penetrates better, thus reduces friction, which in turn reduces the wear on the wire and increases working life.

However, flat top wire is used in wool carding where burr removal is required. It improves the action of burr beating roller provided in the woolen card.

MECHANICS OF FIBRE HOOKS FORMATION IN CARDING AND INFLUENCE OF HOOKS

A large amount of research work has been carried out to investigate the shape of fibres after carding. A classic work by Morton with Summers and Yen using tracer fibre technique revealed that fibres after carding form hooks of different shapes and they divided them into five groups:

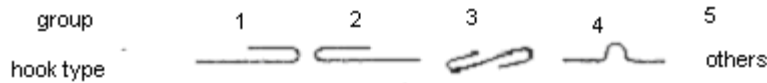


Fig. C28

It was found that majority of fibres were hooked as in group 2. Group 2 hooks are also larger in size than group 1.

Further experiments also proved that majority of hooks in the card sliver are trailing hooks (group 2) and so such hooks are called majority hooks. Leading hooks (group 1) are called minority hooks. Table 1 gives number of hooks of various types counted in experiments conducted on cotton and viscose by Morton and his co-workers:

Table 1

Group	1	2	3	4	5
Viscose staple	16.2	47.8	13.2	20.8	2
Egyptian cotton	10	42	8	25	15

Various investigations conducted over years have proved without any reasonable doubt that hooks are formed at the point of interaction between cylinder and doffer. Therefore, any change in the ratio of speeds between the two effects the number of hooks formed. The actual mechanism of hook formation can be explained by Fig C29.

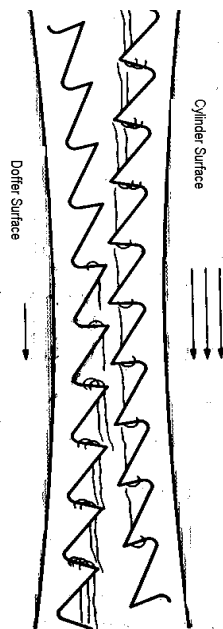


Fig. C29

Before transfer, fibres remain caught at the cylinder teeth. During transfer, projecting ends are caught by doffer clothing. As a result of higher surface speed of cylinder compared to doffer, it sweeps the rest part of the projected fibre (tail) caught by doffer. The tail of the fibre emerges first and so it comes out as a trailing hook.

According to research studies, increased production rates (increase in doffer speed for same cylinder speed) can result in a decrease in the number of minority hooks and increase in the number of majority hooks. With medium and short staple cotton, the later effect (increase in minority hooks) is not significant. Thus, increase in doffer speed can be beneficial in decreasing the total number of hooks. But above an optimum speed, cylinder loading will be high (due to high throughput rate) and quality of carding is reduced.

INFLUENCE OF HOOKS

The presence of hooked fibres in the sliver reduces the effective length of fibre and properties that benefit from length of constituent fibres thereby suffer. For example, if hooks persist into the yarn, the yarn will be weaker and thereby more ends down will be observed in spinning.

During drafting, if a hook is presented as trailing hook, then it gets straightened out. This is because, if fibre is presented to the nip of the front roller, it is suddenly accelerated, but trailing end is caught by more number of slowly moving fibres controlled by the back roller. This results in straightening of hooks. This is shown in Fig C30.

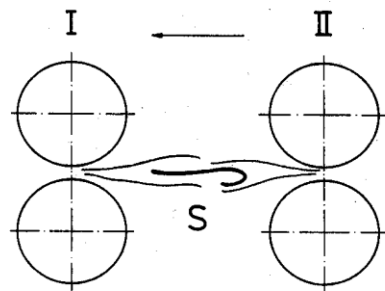


Fig. C30

This is more likely to happen when draft is more. Since maximum draft is available in the ring frame, number of passages between carding and ring frame is so adjusted that

majority hooks are introduced to the ring frame as trailing hooks. Odd number of passages are therefore used between carding and ring frame. This is explained in Fig C31.

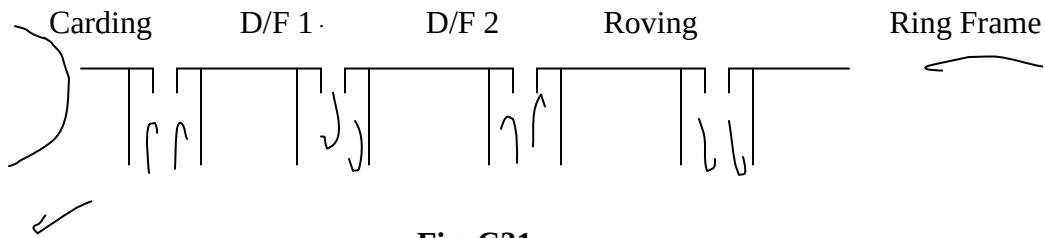


Fig. C31

If a hook is presented to the combing machine as leading hook, it is straightened out by the revolving comb (Fig C32). However, if the hook is presented as a trailing hook, it does not happen and the fibre may be removed as a short fibre; waste in combing will be reasonably high. Therefore, the sequence of operation between carding and combing is so arranged that the majority hooks are presented to combing as leading hooks.

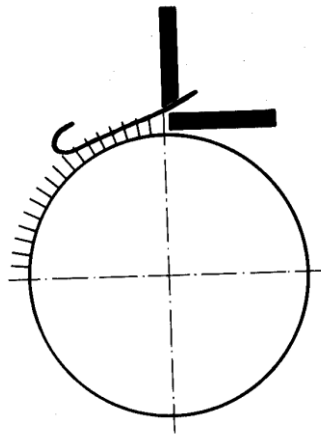


Fig C32

PROCESS PARAMETERS IN CARDING

Settings between different points, wire clothing specifications, speeds of different parts, (such as licker-in, cylinder, doffer, flats etc.), draft, linear density of sliver and feed material, production rate etc. are some of the important factors to be decided while processing fibres of different types in a card.

MACHINE SETTINGS

Optimum opening and cleaning while maintaining minimum fibre damage in carding is achieved through proper settings. Setting basically denotes relative positions and spacing of different components. Since in the same card, within a certain range (which is often quite wide), fibres of different specifications are processed, it becomes often necessary to change the settings. For each specific machine, guidelines of the machine manufacturers should be followed.

The following points are worth considering while selecting any settings:

- The setting between the cylinder and doffer is the closest in the card. The setting primarily depends on cylinder speed, linear density of the sliver and type of wire. For cylinder speed up to 360 rpm, the recommended setting is usually 0.1mm. For cylinder speed above 450 rpm, the setting ranges from 0.125 to 0.15 mm.
- The most critical setting is between cylinder and flats. While processing cotton, it can be as close as 0.175 mm provided the mechanical accuracy of the flat top is good. Setting is open towards licker-in side and gradually narrowed down towards the doffer. Closer the setting less will be the neps. However a very close setting may result in the increase of flat strips. For processing synthetics, the setting is kept relatively wider.
- Most of the cards have 6-11 stationary flats at the licker-in side. This setting may start with 0.4 mm and end with 0.25 mm depending on the machine and material processed.
- Setting between feed plate and licker-in depends upon the type of feed plate. Conventional feed plate setting is decided primarily by the feed weight and, to some extent, by fibre length and type. With the new arrangement of feed plate and feed roller, the setting is decided primarily by the fibre length and, to some extent, by feed weight. Normally the setting is kept around 0.45mm to 0.7mm.
- The setting between licker-in and first mote knife is around 0.25mm to 0.5mm. This helps to remove the heavier trash particles. The setting between licker-in and comber segment is around 0.45mm to 0.6mm. In case of second mote knife, the

setting is around 0.4mm to 0.5mm. This knife helps in removing smaller trash particles.

- Setting between cylinder and stationary flats at doffer side can be as close as 0.15mm. This helps transfer the fibre to doffer by lifting the fibres of the cylinder wire and with better opening. The setting between the knife in the stationary flat and cylinder is very close (around 0.15mm). This removes trash particles of very small size.

WIRE SPECIFICATIONS

Wire conditions and selection of wires are the two most important parameters which influence the performance of modern high production carding machine.

Details about wires and some general specifications have already been discussed. Some additional and important points to be considered while deciding wires for a particular fibre is presented below:

- Wire height and angle depends on the cylinder speed. For higher cylinder speeds, lower tooth angle (apex angle) should be used. Higher the cylinder speed, higher is the centrifugal force created by the cylinder, and this tries to eject the fibres from the cylinder. Cylinder wires have to overcome this effect and retain the fibres. However, too low an apex angle can result less fibre transfer to doffer resulting recycling of fibres and as a consequence, neps will increase. Therefore, angle should be selected judiciously considering speeds and fibre types.
- The effective working depth of a cylinder wire tooth for cotton for high production card is approximately 0.2 mm and for synthetic fibres, 0.4 mm. Man-made fibres require more space in cylinder wires than cotton. Such short wires are called “No space for loading profile (NSL)”. With this low tooth depth, free blade space is reduced which results in low fibre loading and better fibre transfer to doffer. Some general guidelines for wires with cylinder speed should be followed as specified by machine manufacturers.
- A standard doffer wire has an overall effective height of approx. 4 mm to facilitate fibre capture from cylinder. Heavier web requires a deeper doffer tooth with additional clothing capacity to handle the increased fibre mass.

- The doffer wire normally has a smaller land which helps to strengthen the tooth. The extreme small land of around 0.05mm ensures that the doffer wire height is consistent, has no adverse effect on penetration and is considered essential for efficient transfer of fibres from the cylinder. The land has microscopic striations which are created during manufacturing or grinding. These striations help to collect the fibres from the cylinder and keep them under control during the doffing process.
- Doffer wire has a rib thickness of 0.8mm-0.9mm.
- Number of wire points in stationary flats at the licker-in side can start with 140 ppsi (first one) and end with 320 ppsi (last one near the revolving flats).
- Number of wire points in stationary flats at the doffer side is normally 300-400 ppsi. For high production applications, it can be as high as 600 ppsi.

Other Technical Details

Some technical information in respect of some of the known commercial carding machines is provided in the table.

Machine /Model	Max Production (kg/hr)	Width (mm)	Sliver Tex	Licker-in RPM	Cylinder RPM	Doffer RPM	No of Flats
Rieter C 51	120	1000	3.5 - 8.0		300 - 600		104 revolving 40 working
Crosrol MK5D		965	3.5 -7.0	660 - 1500	425 - 770	40-120	89 rev 36 working 8 stationary (cotton) 12 stationary (synthetic)
Crosrol CST(Tandem card)	100	965	3.5 - 7.0	660 - 1500 (breaker) 120 finisher	425 - 770 (breaker & finisher)		89 rev 36 working 5 stationary (cotton)
Marzoli C501	100		3.3 - 6				
Textima 1453/3	53	1000		740 - 930	320 - 400	6 - 36	102 revolving 42 working
SACM HP800		1020		820 - 1300	320 - 600	30 - 100	106 revolving 42 stationary

In most of the modern cards, some online monitoring and adjustment systems are also available. Some of these are:

- Online measurement of neps: for example, Nep control NTC of Trutzschler
- Readjusting setting between cylinder and flat while machine is running; for example, Flat control FTC of Trutzschler
- Grinding while machine is running; example, IGS (Integrated Grinding System) of Rieter

BASIC ROUTINE MAINTENANCE OF A CARD

STRIPPING

Stripping is often required for flexible card clothing in order to clean the wires from the knee, as over a period of time, wire knees get loaded. In the case of metallic clothing, stripping is not usually required, as there is no knee in the wires. However, if the cylinder gets loaded, then problems appear in the running of the card and then, cylinder should be cleaned. This is often done by a hand scraper/ brush while cylinder is rotated slowly. Brushing must be carried out in the direction of teeth and not against them.

GRINDING AND MAINTENANCE OF CLOTHING

Fibre - metal friction results in wearing out of teeth over a period of time. Wire points become round at the top and lose aggressiveness. This results in improper carding and as a consequence, fibre rolling and nep formation increase. In order to re-sharpen the teeth, grinding is therefore necessary. The number of neps gets reduced after each grinding. However, as the number of grindings increases, quality drops due to reduction of height and broadening of land of the wire points. Softer metals are gradually exposed and more frequent grinding becomes a necessity.

The grinding interval depends on factors such as the amount of fibre processed by the card, type of fibre, clothing quality and nep level permitted. The usual practice is as follows.

	<u>Cylinder</u>	<u>Flats (for regrindable flats)</u>
First grinding:	80 - 150,000kg	120 - 150,000 kg

Each additional grinding: 80 - 120,000kg. 80 - 120,000 kg.

For doffer, the grinding frequency is half of cylinder grinding frequency. Grinding is not done for licker-in clothing and it is replaced after 100,000-200,000 kg of fibre processing. This is because there is no land in licker-in wires.

Stationary flats

The work done by the first few stationary flats is very high, and they wear out faster. 50% of the flats are recommended to be changed after 100,000 kg of production and the rest after 150,000 kg of production.

DRAW FRAME

Draw frames are used after carding in yarn manufacturing process. In the case of combed yarn manufacturing, draw frames are used before as well as after combing.

OBJECTIVES

The draw frame has the following objectives to attain:

- Improvement in material evenness
- Parallelizing fibres
- Blending
- Dust removal

Improving Evenness

Draw frame primarily improves medium term and especially long term sliver evenness through doubling and drafting. The number of doublings lie in the range 6 to 8 and so is the range of draft; as a result, the input and output material is almost same in terms of liner density. Drawing is done in two stages; at breaker and at finisher draw frames. Therefore, two passages of drawing with eight ends (sometimes six) each time would produce a single sliver consisting of 64 strands. This helps in reducing variations. In processing of pure comber noil in rotor spinning, the draft is usually kept at 4. It is seen that not much improvement results in terms of short-term irregularity except after combing possibly due to rectifying combing piecing. The concept of comber piecing is presented in the chapter dealing with combing machine.

Parallelization

To achieve an optimal value for the strength of yarn, fibres must be arranged parallel to each other and along the axis of yarn. Draw frame fulfills this task by way of the drafting rollers. The amount of draft to be applied immediately after the card cannot be very high as fibre entanglement is very high and the strand is thick. As such, draft has to be increased gradually.

Mixing and Blending

Drawing is the final stage of quality improvement in a spinning plant before yarn is spun. This is by providing the degree of compensation of raw material variation by blending. This result is exploited in particular, in the production of blended yarns comprising cotton/synthetic or synthetic/synthetic blends. At the draw frame, metering of the individual components can be carried out. As an example, to obtain a 67:33 blend, four slivers of one component and two of the other are fed to the draw frame. However, these slivers must have the same linear density. In the case of differences in linear density, thin slivers will not be gripped properly by the drafting rollers, and disastrous results will be seen due to a group of some fibres drafted away by the front rollers giving very high irregularity and fibre clusters in the drafted strand.

Dust removal

Draw frame is a machine where a very high degree of fibre/fiber friction takes place in the drafting zone; this is ideal for separating dust. Many modern draw frames have appropriate suction removal systems; more than 80% of the incoming dust can be extracted.

ELEMENTS OF THE DRAW FRAME

I. CREEL (SLIVER FEED)

The creel is used to feed the material to the drafting section without false draft by rotatable roller or roller pair provided above each can, one for each sliver. Creels are made of high precision cast aluminum. The creel must be designed:

- To avoid false drafts
- To stop the machine upon a sliver breakage and
- To deal sliver breaks easily, comfortably and safely.

The creel can be of:

- One or two rows
- Short creels for cans up to 600 mm diameter or long creels for larger cans up to 1000 mm diameter
- 6 fold or 8 fold doublings
- Automatic or manual can transfer (in most cases, manual can transfer creels are used).

For better draw frame efficiency, block change of cans at creels is advantageous. However, precise length of sliver at cans is the prerequisite for this. It is also very important that stop motions in the creels work properly. Such stop motions stop the machine when any one of the slivers is broken or creel gets exhausted. This is achieved by the infeed roller pairs which serve as electrical contact rollers for monitoring the sliver. If the sliver breaks, the metal rollers come into contact because the insulating sliver is no longer present between them and the machine is stopped.

The slivers should lie closely adjacent, but not on top of one another, as they run into the drafting arrangement.

II. THE DRAFTING SYSTEM

Drafting arrangement is the heart of a draw frame as it exerts the most decisive influence on quality. The drafting arrangement should be:

- Simple, uncomplicated construction
- Stable design for smooth running at high speeds
- Flexible to handle different types of fibres
- Able to control fibres properly to produce a uniform sliver
- Easy to operate and adjust the settings
- Easy to maintain and clean

Elements of the drafting arrangements in short-staple spinning are:

- Bottom rollers
- Top rollers and

- Fiber guiding devices.

Bottom rollers

In all drafting arrangements, bottom rollers are made of steel and mounted in roller, ball or needle bearings. They are positively driven. These rollers have one of the following types of flutes to improve their ability to carry the fibers along:

- Axial flutes
- Spiral (inclined) flutes
- Knurled flutes

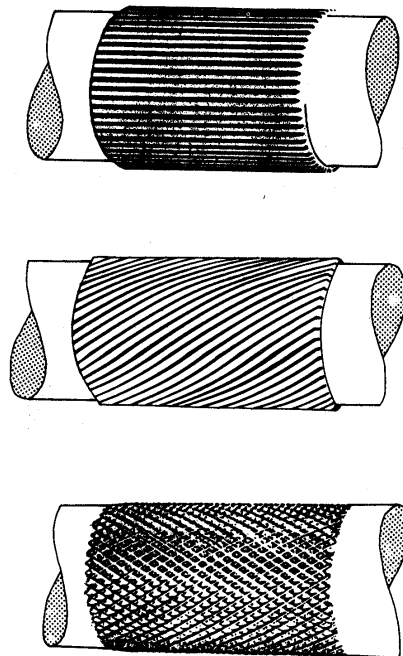


Fig. DF1

Knurled flutes are used on rollers receiving aprons to improve transfer of drive to the aprons. In draw frames, spiral fluting is used mostly because:

- It offers more even clamping of the fibers and lower noise levels in running
- Its draft defects are minimized in the subsequent processes
- Top rollers can roll on spiral fluted bottom rollers more evenly with less jerking and therefore, spiral fluted rollers are preferred for high speed operation.

The diameter of the bottom rollers in draw frames lies in the range 20-90 mm, but normally diameters between 25 and 50 mm are used. The drafting arrangement may

include 3 – 6 bottom rollers. Distances between rollers of the drafting arrangement are adjustable and are adapted to fiber lengths.

Top rollers

Top rollers can be one-piece rollers (draw frames) or twin rollers (roving and ring frames). Top rollers are coated with synthetic rubber. Hardness of this coating is specified in terms of degree shore. They are characterized as follows:

Soft:	60 ⁰ -70 ⁰ shore
Medium:	70 ⁰ -90 ⁰ shore
Hard:	Above 90 ⁰ shore

Soft coats surround the fiber strand to a greater extent than harder ones and thus guide the fiber better, but wear out more quickly. A soft coating is therefore used where good guidance is necessary, i.e. where few fibers have to be moved with high draft levels (e.g. at the front rollers of the ring spinning machines). Otherwise, harder coatings are used.

Ball bearings are used most exclusively in top roller mountings. The top roller synthetic rubber is periodically ground (called buffing) in order to maintain the roundness and smoothness as the coatings wear out during spinning. The grinding operation has a roughening effect on roller surface which leads to formation of laps when processing sensitive fibers. For better smoothness after buffing, roller coatings can be treated with:

- Applying a chemical film such as lacquer or another smoothing medium
- Acid treatment
- Irradiation by UV-light

To clamp the fibers, top rollers must be forced at high pressure towards the bottom rollers. This pressure can be applied by:

- Dead weights (now obsolete)
- By Spring weighting (more common)
- Pneumatic weighting (Rieter) – mostly used in modern draw frames.
- Magnetic weighting (Saco Lowell)
- Hydraulic systems (hardly used)

Fiber guidance in the drafting zone

1. Aprons

Aprons have been introduced in the main drafting zones of the speed frame and the ring frame to achieve better fibre control. These aprons move at the surface speed of the slower pair of rollers. The fibres are highly compressed between two aprons. The cradle opening (the gap between the two aprons near the front roller nip) is adjustable, and there is an optimum setting for yarn regularity and spinning performance. A close setting between the front end of the aprons and the front roller nip is possible because the aprons can be guided round stationary tensor bars without danger of fibre lapping. This reduces the number of floating fibres and thereby permits a high draft up to 40. The aprons are made of synthetic rubber like laminates which offer a long working life, high tensile strength and resistance to fibre additives. Aprons are used in both cotton and worsted spinning. Aprons cannot be used successfully on draw frames because of the high material mass - the fibres in the sliver are not effectively controlled, and the consequent slippage at the aprons leads to wear and variation in draft. The greater width of aprons also contributes to slippage.

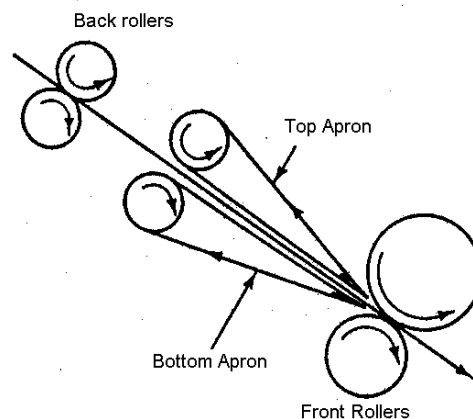


Fig. DF2

2. Pin Control

Pin Control is used only in the case of long fibres where a suitable device can be fitted between two pairs of rollers. Such draw frames are known as gill boxes and used in long fibre spinning process (worsted and semi-worsted). If pins penetrate through an already tensioned sliver, the pressure between the fibres will be increased and so a better friction

obtained. Pin control also helps to minimize fibre entanglement and nep formation, particularly with fine fibres.

The amount of inter-fibre and fibre-metal pressure depends on pin length, thickness, population density and depth of penetration as well as on the fibre density of the sliver processed. A side view of a sectional diagram of an intersecting gill box is shown in Fig. DF3.

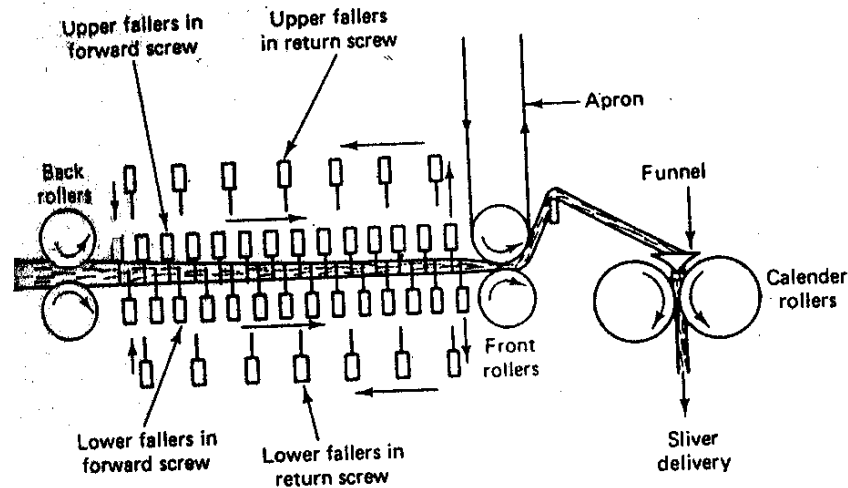


Fig. DF3 Intersecting gill box

The fallers are bars which carry a row of pins along their length (which is parallel to the axis of the rollers); they are usually supported by a metal 'saddle' near each end, and driven by a rotating screw at each end. As each faller approaches the front pair of rollers, it is knocked off by cams so that pins are withdrawn from the fibres and fallers then move backwards by a return screw. The forward surface speed of the fallers on the intersecting gill box is usually about 5% faster than the back roller surface speed. The distance from the back roller nip to halfway along the faller bed is usually longer than the longest fibre being processed. The closest distance from the foremost faller pin to the front roller nip is called the front ratch, and it is usually set at the minimum distance permitted by the mechanism.

The principle of fibre control is that a thick twist-less body of fibres is fed forward at the faller speed until fibre is gripped by the front pair of rollers. Fallers can either be driven

by a screw or a chain. Screw cannot run very fast and is also responsible for a higher noise level. Chain fallers can run at a speed of about 5000 faller drops/min (number of faller transferred from forward to the return path), compared to about 2000 drops/min for high speed screw driven faller.

The draft applied in gill-boxes on merino wools is usually 6 to 8 on Bradford type (for long wool) and 8 to 10 on other types.

3. Pressure bar

This method of direct pressure control was introduced in 1960s by Platt on cotton draw frames where owing to the short fibre length, there is not much room available for fibre control devices. Stationary pressure bar (Fig. DF4) “A” deflects the sliver as it approaches the front roller nip and thereby applies lateral pressure which helps to control the floating fibres by preventing them running fast until nipped by front pair of rollers. The setting of the top middle roller B at the center of the respective bottom roller C is linked to the pressure bar, maintaining the distance between the centers of A and B constant. Front roller D can also be moved about the center of the lower roller E so that a wide range of lengths can be accommodated with optimum settings and drafts ranging from 4 to 10.

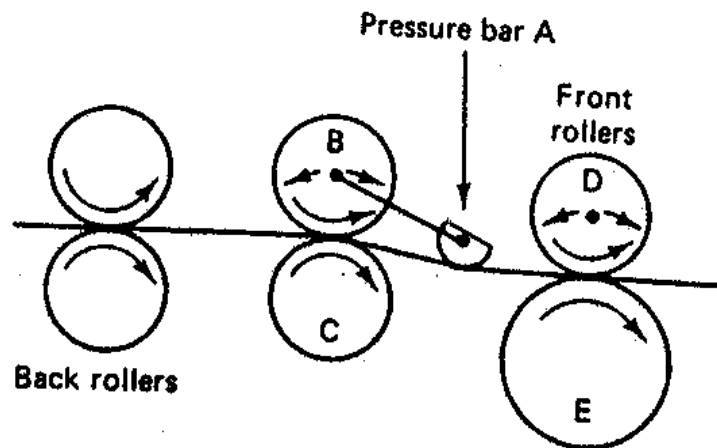


Fig. DF4

This is one of the most widely used arrangements in modern draw frames and is found in Rieter, Schubert & Salzer and Toyoda draw frames.

4. Staggered roller arrangement

Fibre control in draw frame of short staple spinning is achieved in many modern draw frames by staggered roller arrangements usually coupled with a pressure bar. Early draw frames had almost exclusively 4-over-4 roller drafting systems. The 3-over-4 roller system is a modification out of this earlier version and thereafter, a multitude of new forms emerged. Processing is carried out exclusively in two drafting zones. In extreme cases, the break draft lies between 1.05 and 2.5, but the usual break draft is between 1.25 and 1.8. Maximum total draft ranges between 3.5 and 12, but the usual draft range is between 4 and 8.

All these systems incorporate extra control rollers in the main drafting zone. The fibres are made to rub over a roller surface through a certain arc on leaving the slower pair of rollers; this arc creates required frictional forces. Some of these staggered roller arrangements are described below.

3-over-4 roller drafting arrangement (Marzoli draw frame): Fig. DF5

The characteristic feature of this arrangement is the engagement of the middle pressure roller with two bottom rollers. The two bottom rollers are carried in a common cradle and are not adjustable relative to each other. A pressure bar can further be included in addition to this staggered arrangement. Marzoli draw frame is an example.

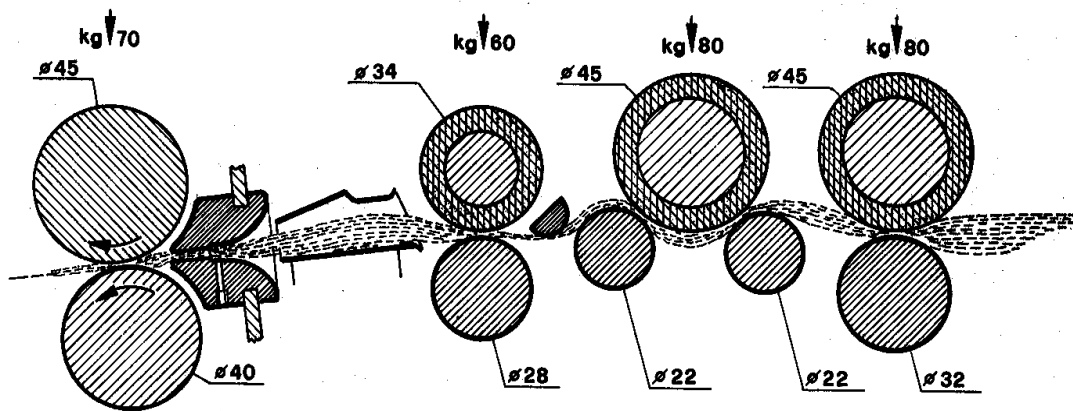


Fig. DF5

4-over-3 roller drafting arrangement with pressure bar (Zinser draw frame): Fig .DF6

Strictly speaking, this is also a 3 roller pressure bar drafting arrangement. A fourth roller with somewhat lower loading is added to the delivery roller to act as a guide. This leads the drafted web directly in to delivery trumpet.

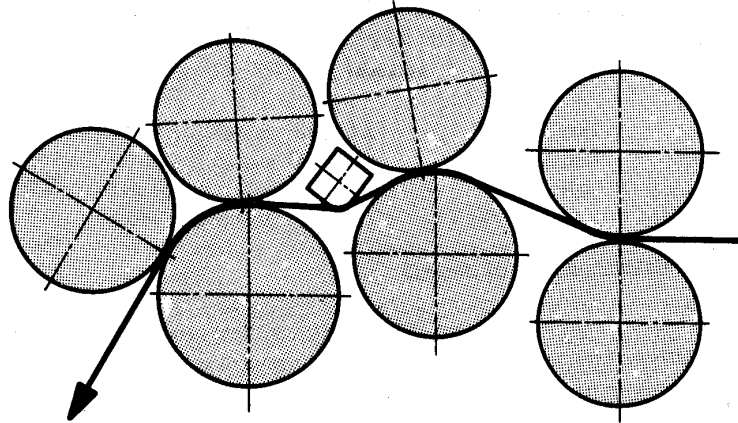


Fig. DF6

5-over-4 roller drafting arrangement (Rieter): Fig. DF7

There are two large (90 mm) and two small (28 mm) bottom rollers. All roller arrangement is over an arc of a circle. Top rollers are 39 mm in diameter, but three middle rollers may be replaced by rollers of 28 mm diameter if required. 'B' is the break draft zone and 'A' is the main draft zone. The nip spacing can be adjusted by radial shifting of rollers 2 and 4. In the main drafting field, a pressure bar ensures firm guidance of floating fibres. The curved disposition makes roller setting and maintenance easy.

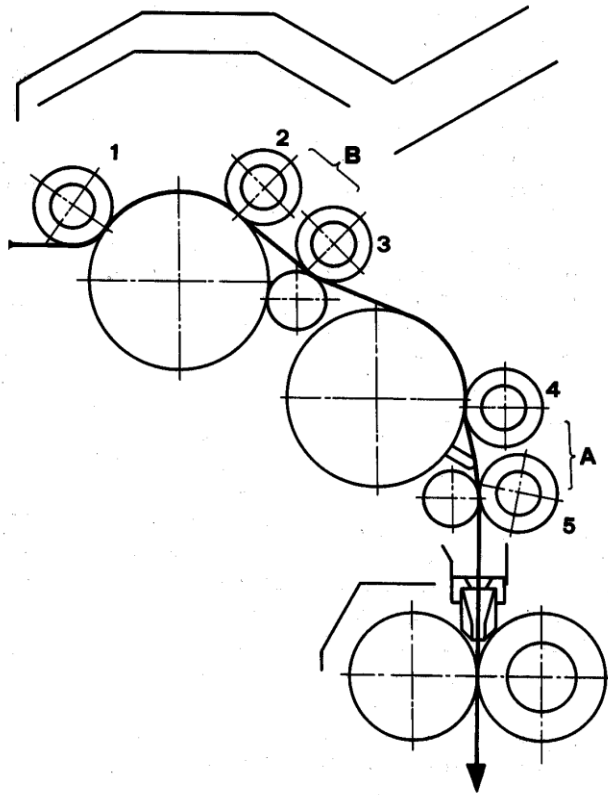


Fig. DF7

DRAFT AND ATTENUATION

A carded sliver contains 20,000-40,000 fibres in cross-section. In a yarn, the number of fibres in the cross section is approximately 100. Therefore, while converting a sliver to a yarn, fibres must be distributed over a greater length so that the cross section is gradually reduced. This gradual reduction of the cross section is called “attenuation” and happens because of extending fibre strand to a longer length by slippage of fibres over one another. Extension of the length is called drawing. The amount of extension of length is called draft. If there is wastage, then attenuation will be more than expected due to draft. So,

Attenuation = Draft $\times$ 100/ (100-P) where, P is the percentage waste.

Attenuation is the “actual draft” and it can be calculated by determining the ratio of input linear density to output linear density (tex system). The ratio between the speeds of the delivery and feed of the drafting device is called “mechanical draft”.

ROLLER DRAFTING PRINCIPLE

Drafting is mostly carried out by pairs of rollers. Fibres are firmly nipped between the bottom steel rollers and pressured top rollers. If the rollers are so rotated that their peripheral speed in the fibre flow direction increases gradually, then drafting takes place. The drafting arrangement illustrated in Fig. DF8 has two drafting zones, namely,

A break draft zone (B): Draft (D_B) = $\frac{V_2}{V_3}$

A main draft zone (A): Draft (D_M) = $\frac{V_1}{V_2}$

$$\text{Total Draft } (D_T) = \frac{V_2}{V_3} \times \frac{V_1}{V_2}$$

Where V_1, V_2 and V_3 are the surface speeds of the respective rollers as shown in the figure.

Total draft is always the product of the individual drafts.

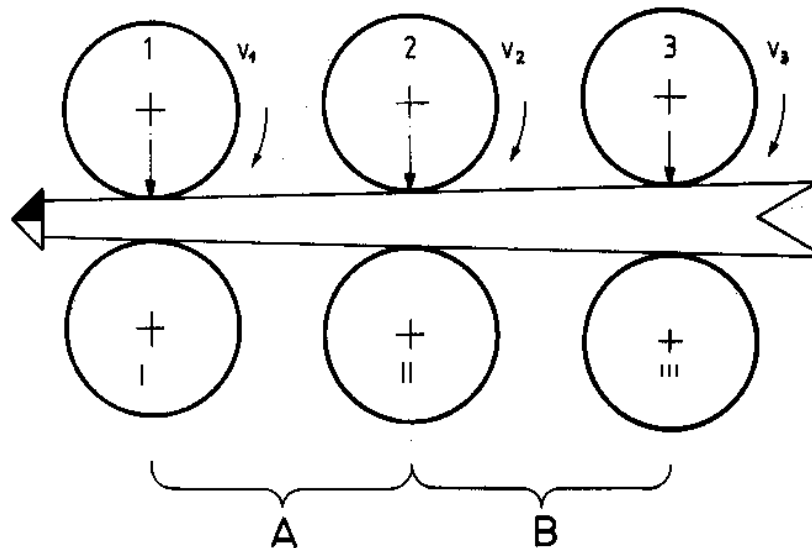


Fig. DF8

III. SUCTION SYSTEMS FOR THE DRAFTING ARRANGEMENT, Fig. DF9.

The suction system helps to remove dust laden air. It also tries to suck any of the fibres that tend to wrap around the rollers and thus helps in preventing roller lapping. The air is passed via a tube directly into the exhaust system of the factory's air conditioning system or to filters within the machine.

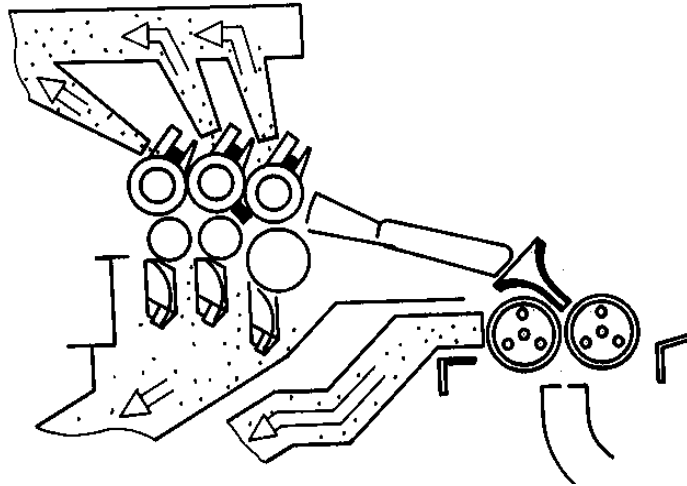


Fig. DF9

IV. DELIVERY AND COILING

Material coming out of the drawing frame does not have much cohesion. As such, in high speed operation, drafted material is immediately converged through a tube (1) and guided to the trumpet (2) [Fig. DF10]. The diameter of trumpet (d) depends on the sliver linear density. Usually $d = k\sqrt{ktex}$; where $k = 1.6-1.9$. For synthetic fibres, bigger coiler tubes are used. This will help to avoid coiler choking and kinks in the slivers while coiling in the can.

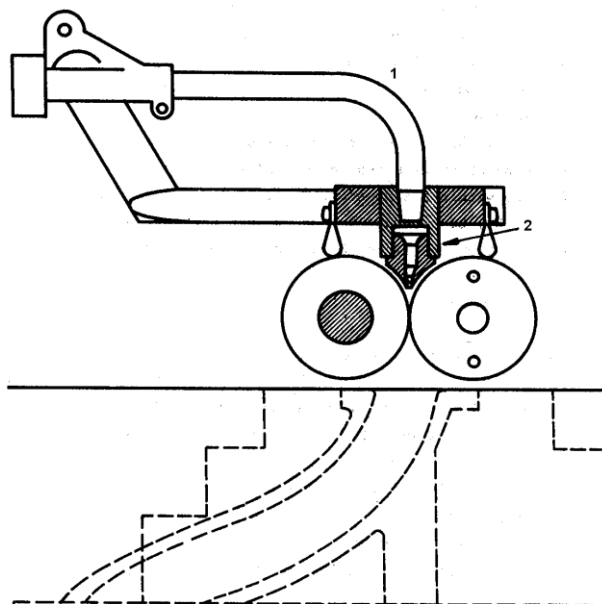


Fig. DF10

The sliver is immediately condensed by calendar rollers following the trumpet. Condensing by calendar rollers is necessary in order to fill up the can with more material. While the sliver is deposited into the can, both the can as well as the plate on the top having a tube through which the sliver travels rotate; such rotation helps to deposit the sliver in the form of a cycloidal coil. The tube extends from the center of the plate to the periphery. The circumferential velocity of the deposition point is somewhat higher than the delivery speed so that blockage of the sliver is avoided. However, difference should not be very high to avoid false drafts. The sliver may be laid in the can in small coils (under-center coiling) or in large coils (over-center coiling).

In modern high-performance draw frames, full cans are changed automatically with empty cans. Can changers are classified into:

1. Single-step changers (flying change): give higher machine efficiency because full cans are replaced by empty ones at full speed, i.e. without stopping the machine
2. Multiple-step changers (interrupted change): give lower machine efficiency because the machine is stopped during can changing.

In some machines, rectangular cans are also used. The speed of the coiler can also affect the coiling. Speed of the coiler should be selected properly. In some modern draw frames, any coiler speed can be selected. Since the option is open, there is also more probability for making mistakes. One should take enough care to set the coiler speed properly.

Number of Draw Frame Deliveries

Although traditional draw frames have two deliveries, many modern draw frames fitted with autolevellers have a single delivery. Autolevellers adjust the draft depending on the thickness variation of slivers. In case two deliveries are used, while correcting material in one delivery, the other will get changed since drive to both the deliveries are common and this is not desired. Therefore, single delivery is preferred when autolevellers are fitted in the draw frames.

SOME IMPORTANT PROCESS PARAMETERS

TOP ROLLER WEIGHTING

Top roller weighting must be greater when:

- Material thickness is more
- Fibre strand is softer
- Top roller shore hardness is low
- Bigger rollers are used.
- Friction is low between fibres and roller surface and also between fibres.

No method is available to precisely calculate the pressure required to be applied and depends on the factory practice.

Any fibre presented to the nip of the front pair of rollers should be immediately accelerated by that pair of rollers and no slippage should take place. Due to this reason, front roller should have a higher pressure. However, too strong pressure increases the wear of elastic cover. In modern draw frames, more pressure is often applied with reduced settings. As the settings become closer, it becomes necessary to increase the pressure due to increase in drafting force; otherwise roller slippage will occur.

ROLLER SETTINGS

Roller setting is primarily fixed on the basis of fibre length and fibre length distribution. In addition, it also depends on the position of the drafting arrangement in the spinning sequence. As already discussed, as the material is drafted, fibre group extent becomes smaller and so settings can be closer in subsequent processes. Each machinery manufacturer, depending upon the drafting arrangement, recommends their own settings for different types of fibres and there is no precise formula for setting suitable for any type of machines. For example, the following settings are suggested for 3-over-3 pressure bar system by one of the manufacturers.

For 1st draw frame

<u>Fibre Effective length</u>	<u>Sliver Count</u>	<u>Front drafting zone</u>	<u>Back drafting zone</u>
Up to 1 1/16	0.08-0.12	EL+1/4"	EL+7/8"
	0.12-0.16	EL+3/16"	EL+3/4"

For 2nd draw frame

Up to 1 1/16	0.08-0.12	EL+1/32"	Fixed
	0.12-0.16	EL+3/32"	Fixed

In modern factories, instead of Effective length, 2.5% span length, upper half mean length, etc. are used in determining the settings as provided by instruments such as fibrograph, HVI (High volume instrument), etc.

Another general rule for roller setting in the break draft region for 3/3 or 4/3 drafting system is as follows:

1. For cotton, Longest fibre + (8 to 12 mm)
2. For synthetic fibre, Fibre length + (20 to 30% of fibre length)

DRAFT DISTRIBUTION

In every drafting operation, irregularities are introduced. If the irregularities introduced are not from the same drawing zone, then, total irregularity can be correlated as follows:

$CV \text{ (Total)} = \sqrt{(CV_1^2 + CV_2^2 + \dots + CV_n^2)}$, where n is the number of intermediate drafts and CV is coefficient of variation.

Thus, the resulting irregularity will be less than the irregularity which might have been caused by drawing the strand in one drawing zone since CV is proportional to the draft being employed in a single drafting zone. This was the reason for drafting being carried out in number of times. Old draw frames used to have four drafting zones. However, due to improvement in design, much better control of irregularities are achieved and so in all the modern draw frames irrespective of the roller arrangement, basically two zones are used; the break draft zone and the main draft zone. The draft in the break draft zone is required to prepare material for drafting in the main draft zone by reducing the entanglements to some extent. The break draft, as discussed in an earlier chapter, should be outside the stick slip zone. For cotton, the recommended break draft is between 1.16-1.26 and for synthetics, between 1.42 –1.6. The total draft is from 4 to 8. The total recommended range of draft for cotton is 7.5 and for the synthetics 8.

SLIVER LINEAR DENSITY

The recommend sliver linear density for cotton is around 3.8-4.2 ktex. For synthetics, since the friction is high, sliver linear density should be below 3.8 for better drafting.

SHORE HARDNESS:

For draw frames, the recommended shore hardness of top rollers is 80 degrees.

BUFFING SCHEDULE

For better performance, buffing should be carried out once every 30 days.

V. MONITORING AND AUTOLEVELLING

Monitoring systems can be classified according to whether they monitor:

1. The machine
2. Production or
3. Quality

Machine monitors are provided to ensure that the machines are stopped immediately if a sliver breaks or runs out, if a lap forms and so on. Otherwise, considerable damage can be caused to the machine.

Production monitors respond primarily to interruptions in operation of the machine. They also calculate the efficiency of the machine and the quantity produced.

Quality monitors are of three different types: displays, self-compensation and autolevelling.

Monitoring devices with displays

These are devices that detect faults but do not correct them. Where these systems are used, the delivered slivers are continually checked for hank constancy (and in some cases also for evenness over short lengths). If an unacceptable deviation from set value arises,

this fact is indicated and the machine is usually stopped. Equipment of this kind increases operational reliability and saves sorting of the product.

Monitoring devices with self-compensation

The so-called “toothed roller leveler” consists of a toothed roller pair (1) and a fluted/pressure roller pair (2) [Fig. 12, p.37, vol.3] forming a small drafting device in front of the actual drafting arrangement. As the individual slivers pass through, they press the two toothed rollers apart by an amount corresponding to the sliver volume.

A thin sliver permits the upper roller to penetrate more deeply into the inter-tooth spaces of the lower roller. This gives greater diversion of the fiber strand at the point where it passes through, which is equivalent to an increase in the circumference of the roller. This results in a higher peripheral speed. Since the peripheral speed of the roller pair (2) remains constant, the draft is reduced between the roller pairs because $D = V_2/V_1$. A thin place is thus drawn to a lesser degree than a normal piece of sliver. If a thick place passes through, the opposite is true.

The measuring and adjusting points are identical and the reaction is thus very fast. A fault in an individual sliver is reduced to about 40 – 50%. However, it is not possible to set a desired value.

Monitoring devices with autolevelling systems

The objective of an autoleveller is to measure the volume of fibers passing through (sliver thickness variations) and then continuously alter the draft accordingly so that more draft is applied to thick places and less to thin places to deliver less irregular sliver than it otherwise would have been.

Autolevellers may be classified in to three main groups according to the basic principle of operation: Open-loop, closed-loop and combined-loop autolevellers.

I. OPEN-LOOP AUTOLEVELLERS

They compensate variations of short (to medium) wave length. The open loop system is shown in Fig. DF12. The solid lines indicate the flow of material through the machine and broken lines represent the flow of information in the autoleveller unit. A measuring sensor is provided in the region of the infeed for continuous detection of the actual value (volume) mechanically, optically, pneumatically or capacitively. A control unit compares the result with the set reference value (related to the mean count of the material), amplifies the difference signal and feeds it to an adjusting device (actuator or regulator unit) which finally converts the impulse into a mechanical adjustment. Therefore, control unit accordingly increases, decreases or leaves unaltered the output of the regulator. The actuator (regulator) provides a variable speed either to the back or front rollers to give the required draft when the measured material reaches the point at which the draft is applied. Since material has to travel a certain distance between the measuring and adjusting points, and therefore arrives at the adjusting point with a time delay, this control requires an additional element, namely a store. The signal must be held back in the store according to the time delay required.

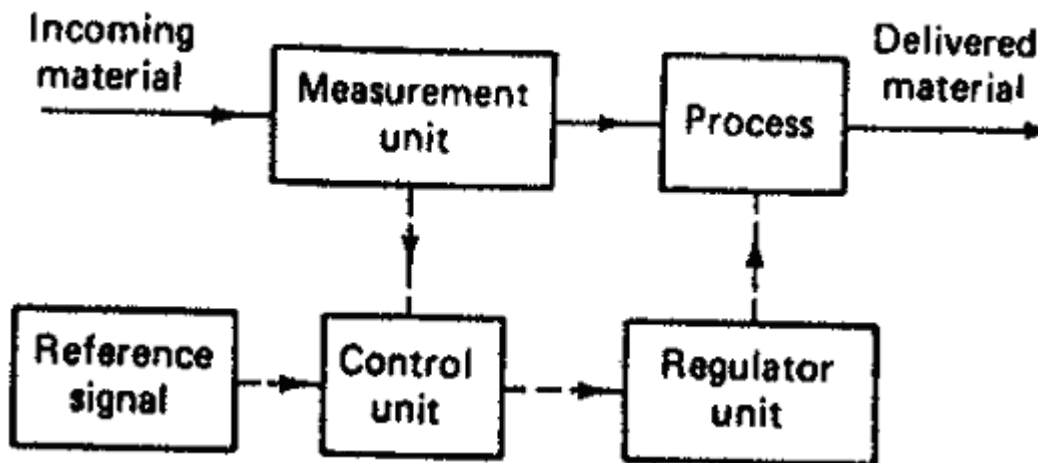


Fig. DF12

If the direction of the arrows in the above figure is followed from any starting point, it always leads 'out into the open' at a place marked delivered material. Since measurement is made on the input material, the correction may either be applied to the back or front rollers as shown in Fig. DF14 (a) and (b).

Advantages:

1. It is easier to design than closed-loop autolevellers
2. It reduces short-term irregularities (variations)

Disadvantages:

1. It lacks self-monitoring, i.e. no check on the delivered material by the control unit
2. It requires an additional element – the store
3. It cannot compensate for long-term variations
4. It requires very exact values of the adjustment at all times

e.g. Most autolevellers in worsted spinning processes.

II. CLOSED-LOOP AUTOLEVELERS

It is designed to correct medium-and long-term variations. The principle of operation is illustrated in Fig. DF13. If the direction of the arrows is followed from any starting point, except the delivery, it always leads to a never-ending circuit of the loop which links the process and the control unit, hence the name ‘closed-loop’.

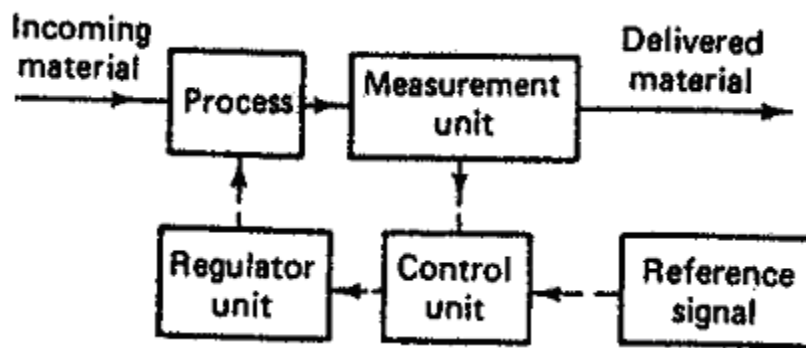


Fig. DF13

Measurement always takes place on the material after the point where corrective action is applied. Thus, if measurement is made on the output, the correction may be applied to either the back (usually) or front rollers of the main drafting zone as shown in Fig. DF14 (c) and (d). No store is required. Also, the actual value does not have to be established as an absolute value, but can be derived as negative (reduce speed due to more material), positive (increase speed) or neutral pulses.

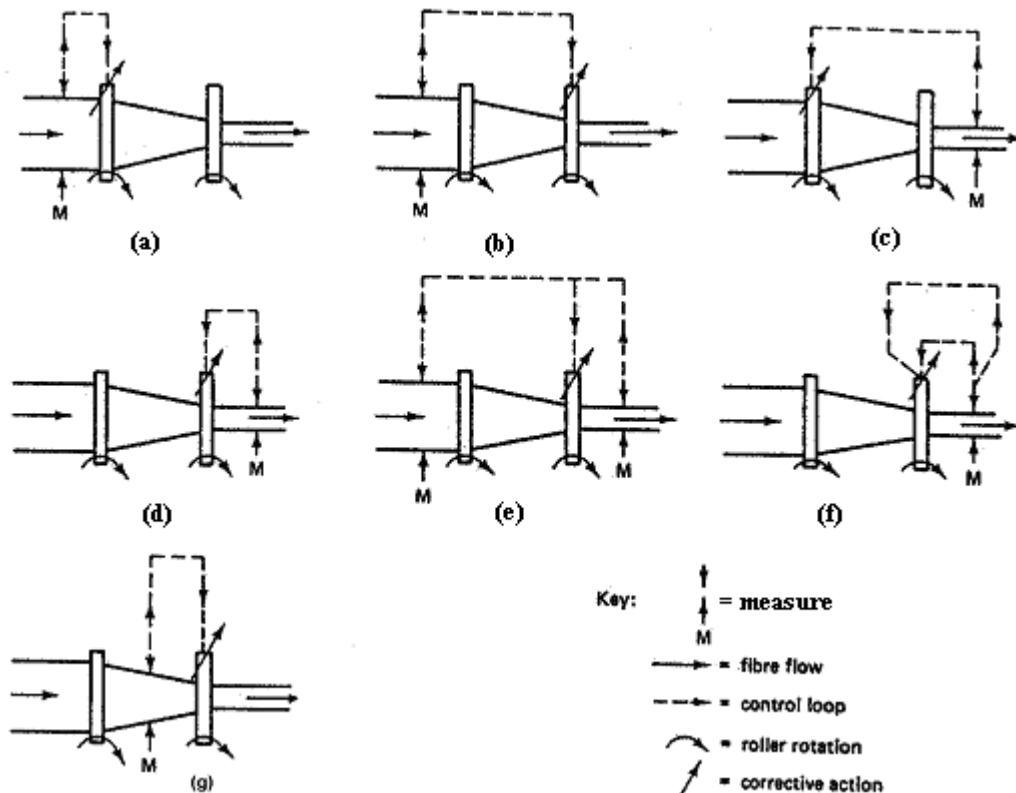
Advantages:

1. Simpler than open-loop control in operation as no store is required

2. Self-monitoring, i.e. measurement always takes place on the material after the point where corrective action is applied. Therefore, the control unit continuously checks the results of its action.

Disadvantages:

1. It is more complicated to design, especially to avoid hunting, i.e. an unwanted oscillation in the out put
2. Dead-time inherent in the system. The measured portion as long passed the adjusting point when the adjusting signal arrives. Compensation of this measured portion cannot be achieved; i.e. some of the long-and medium-term errors with all of the short-term errors remain in the product.



Types of autoleveller control systems: (a) and (b) - open loop systems; (c) and (d) - closed loop systems; (e) - open and closed loop combined; (f) - fast and slow loop combined; (g) - intermediate measurement

Fig. DF14

III. COMBINED-LOOP AUTO LEVELERS

A combined evenier draw frames can be designed to correct short, medium and long-term variations.

Various loop arrangements are used:

- A) To avoid the disadvantages of both open-and closed-loop control principles, open-loop and closed-loop devices are combined into an integrated autolevelling system [Fig. DF14 (e)]. Capacititive sensing is generally used in the infeed and mechanical or pneumatic sensing in the delivery. An open-loop corrects short-term irregularities with a fast response and long-term stability is provided by the closed-loop.
- B) Combination of two separate closed-loops [Fig. DF14 (f)].
- C) Measurement on the material of intermediate thickness between back and front rollers of a drafting zone [Fig. DF14 (g)]. Since the sliver thickness at the point of measurement depends on both the input and output fibre end densities, this is a combined-loop autoleveller.
- D) Use of drafting force to measure of sliver thickness within a drafting zone

Adjustment points

Adjustment can be made either on feed or delivery rollers in any autoleveller. Altering feed roller speed is usually used to change the draft. Change of delivery speed would among other things lead to continuous changing of production and change of speed of large masses, such as coiler cans and their associate drives. Moreover, since the speed of the delivery is high, more acceleration and deceleration will be required. However, if integrated draw frames are used (cards and draw frame combined), then constant infeed speed is required to maintain synchronization and then delivery roller speed needs to be changed.

COMBING

OBJECTIVES

Combing is a process employed to perform the following tasks:-

- Elimination of a precisely pre-determined quantity of short fibres.
- Elimination of remaining impurities after blow-room and carding.
- Elimination of neps

As a result of the combing operation, particularly due to elimination of short fibres, spinnability of the fibre increases. After combing, marked improvement of the following properties of yarn is noticed:-

- Yarn Evenness
- Strength
- Cleanliness
- Smoothness and
- Visual appearance

Negative effects of combing

While performing the required tasks, combing by its own action produces two defects in the sliver.

- Piecing defects. This will be discussed later and as will be seen, that with proper measures, it can be minimized.
- The high degree of parallelization of fibres in the combed sliver may reduce the inter fibre cohesion to such an extent that it may lead to breakages in creels or false drafts in subsequent processes. So, combed sliver should be carefully handled in subsequent operations.

AMOUNT OF NOIL IN COMBING

Noil is the material removed by comber, which includes fibres, trash and neps.

The amount of noil can be expressed in two different ways:

$$1. \quad \% \text{ Noil} = \frac{\text{MassOfNoil}}{\text{MassOf}(\text{Noil} + \text{CombedSliver})} \times 100$$

$$2. \quad \text{Tear Ratio} = \frac{\text{MassOfCombedSliver}}{\text{MassOfNoil}} : 1$$

$$\text{Tear Ratio} = \frac{100}{\% \text{Noil}} - 1$$

The tear ratio is mostly used in the worsted sector, whereas % noil is used in cotton spinning process.

The amount in combing noil depends on the type of yarn to be spun and also on the quality of fibre. In cotton industry, the range is 5-30%. Accordingly, combing can be divided into the following groups.

Long staple combing factories:- These factories produce fine to superfine yarn and also use high grade fibre having long staple and low trash. Percentage noil in combing is kept high. Production in combing is low

Medium staple combing factories:- Yarns spun are medium to fine in count. Medium staple and middle grade fibres are used. Noil level is moderate. Such mills tend to produce high grade yarn and combing production also is maintained at high level. However, it requires good technology and practices to maintain both quality and production and also medium level of noil at the same time.

Short to medium staple combing factories:- Raw material used here is the same as that for the production of carded yarn. Yarn count range is medium and sometimes, low to medium. Percentage noil is kept low (6-14%). Production in combing is high.

Light combing is also introduced to a greater extent owing to the impairments in cotton quality influenced by mechanical harvesting. Even when minimum noil is removed, there is a noticeable improvement in the fibre parallelisation in sliver; smoothness and shining of the yarn is improved.

A practical example of quality improvement through combing

To produce 30s to 40s count, cotton fibres with the following properties are used:

2.5% span length=28 to 30 mm

Uniformity ratio=50 to 53 %

Floating fibre Index (FFI)= 6 to 14

Micronaire=3.8 to 4.2

Bundle strength=24 to 28 g/tex

In order to meet the quality requirements for achieving 5% Uster statistics for important yarn parameters (in terms of quality, rank is 5 out of 100), % noil required in combing is 15% to 18 %.

COMBING EFFICIENCY

It is usually calculated based on the % improvement in 50% Span length over noil removed.

$$\text{Combing efficiency} = \frac{S - L}{L \times W} \times 100$$

Where; S= 50% span length of combed fibre

L= 50% span length of uncombed fibre

W= % noil

RECTILINEAR COMB

This type of combing machine is used in the cotton spinning industry and is increasingly being used in the worsted industry as well. This was invented by Heinemann in 1846 for cotton, and was further developed in 1902 by Nasmith. Machines are usually single sided with 8 heads (can be up to 12). Double sided machines are also manufactured by Plat Saco-Lowell. The slivers delivered by the heads are conveyed along a transverse front table to be fed as doublings into a draw box at the end of the machine.



Fig Cm-1

COMBING CYCLE

The combing cycle of a rectilinear comb is presented in Fig Cm-2. The steps are as follows:-

Feeding (Fig Cm-2 (a)):- The feed rollers “S” move the sheet “W” by 4-6.5 mm forward, while the nippers “zo”/ “ zu” are held open as shown in figure.

Nipping (Fig Cm-2 (b)):- - The upper nipper plate “zo” is lowered into the cushion plate zu in order to clamp the fibres.

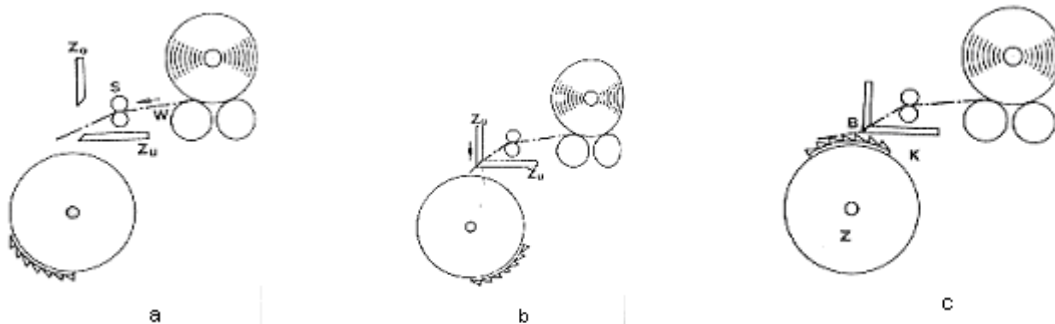
Initial combing (Fig Cm-2 (c)):- The combing segment “k” mounted on a rotating cylinder “z” sweeps its needles or saw teeth through the fibre fringe “B” and carries away any thing not held by the nippers.

Nipper opening and forward movement (Fig Cm-2 (d)):-The nippers open and continue to move towards the detaching rollers.

Web return and piecing (Fig Cm-2 (f)):- Meanwhile the detaching rollers A have returned part of the previously drawn off web by means of a reverse rotation. At the same time, forward movement of the nippers place the projecting fibre fringe “B” upon the returning web “v”.

Final Combing by top comb and detaching (Fig Cm-2(g)):- The detaching rollers begin to rotate in the forward direction and draw the clamped fibres out of the sheet “W” held fast by the feed rollers.

However, before the start of the detaching operation, the top comb “F” penetrates in to the fibre fringe; as the fibres are pulled through the top comb, the trailing part of the fringe is combed.



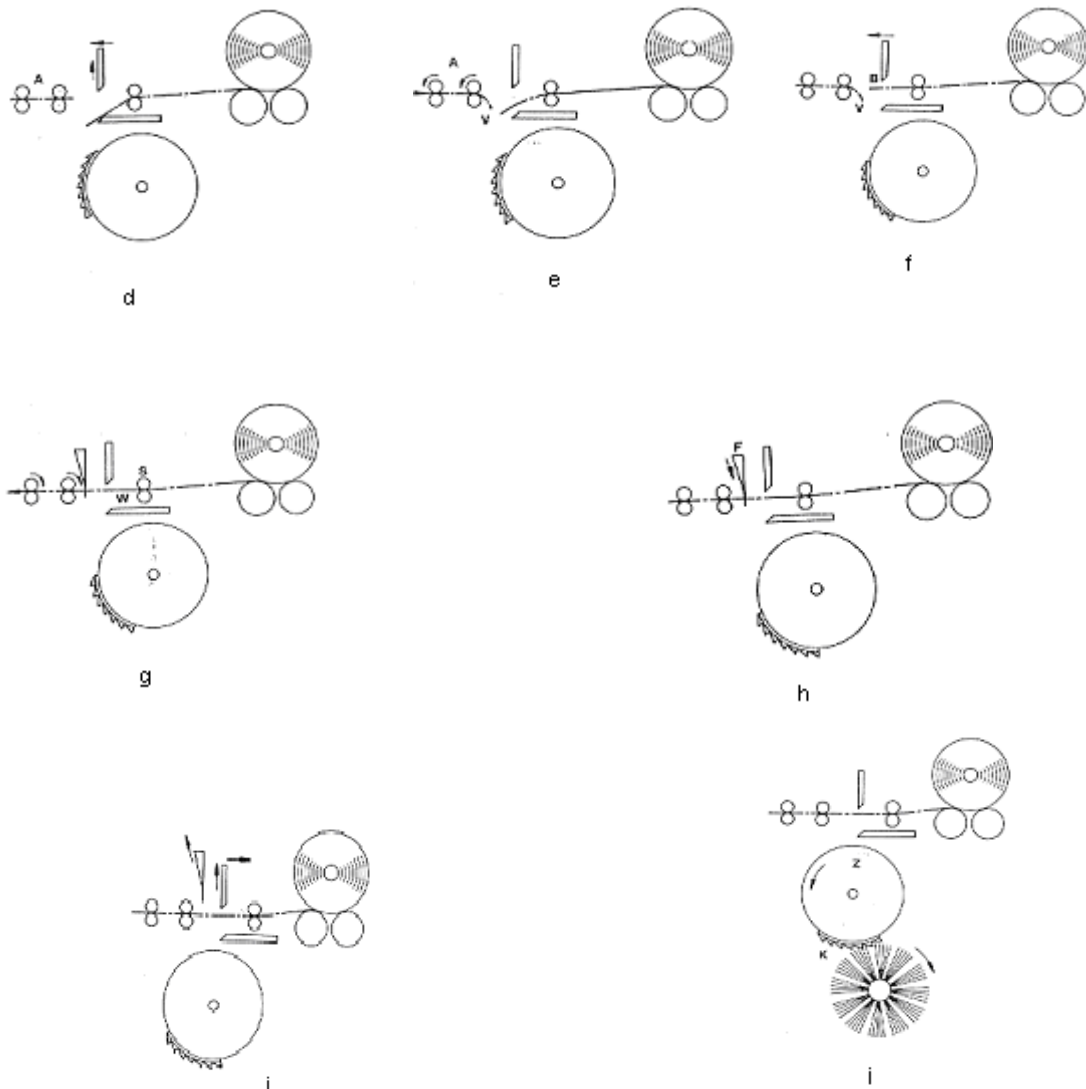


Fig Cm-2

Nipper returns: (Fig Cm-2 (i)):- As the nipper assembly is retracted, the top comb is withdrawn and next cycle begins.

Comb Cleaning (Fig Cm2-2(j)):- The combing cylinder continues to rotate and the combing segment is brought into the vicinity of the rapidly rotating brush mounted below the combing cylinder. The brush cleans the combing segment and makes it ready for the next cycle. The noil is transferred to a collecting chamber. The nipper assembly is shown in Fig Cm 3.

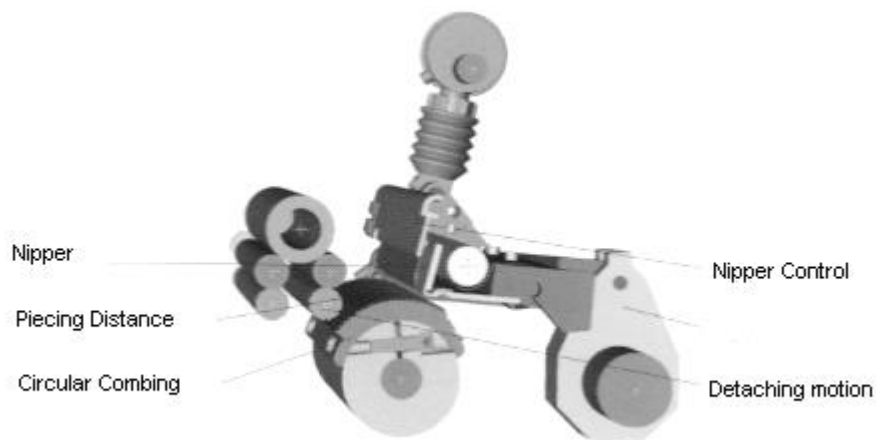


Fig Cm3

TIMING DIAGRAM

Comber timing diagram indicates the functions of different elements during a combing cycle. An index wheel has forty graduations with marked “1-39” as shown in the Fig Cm-4. The index wheel is used to adjust the settings of different elements. The timing diagram in the figure is taken from Rieter E 7/5 combing machine.

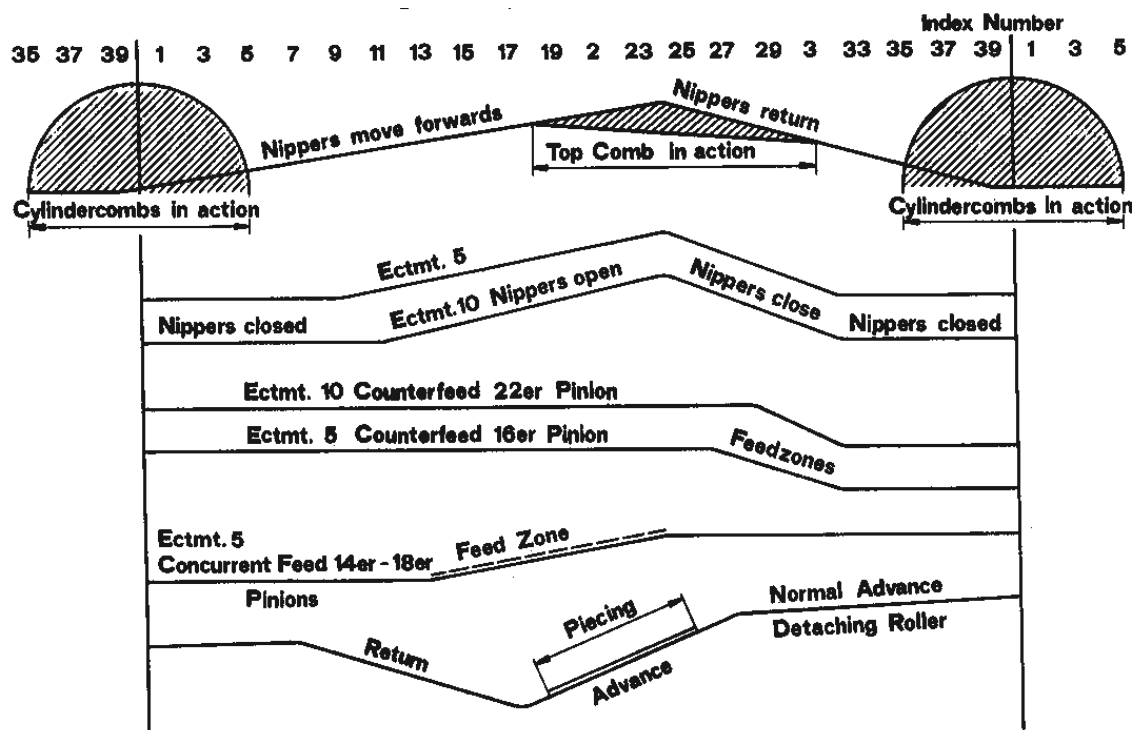
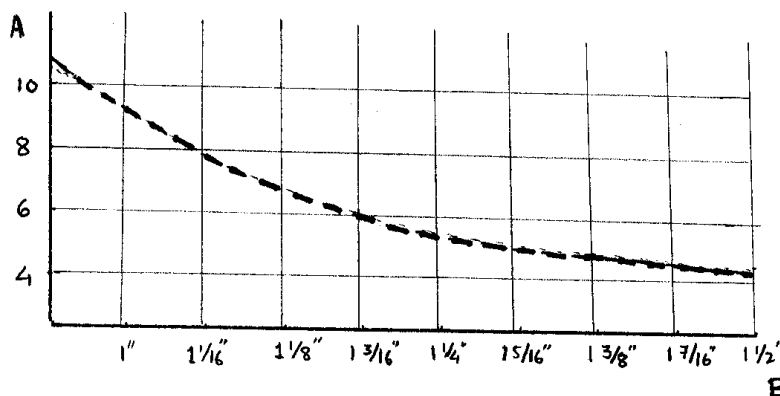


Fig Cm-4

PARAMETERS INFLUENCING THE COMBING OPERATION

MACHINE SETTINGS

Feed distance:- This indicates the distance fed by the feed roller per cycle; high feed distance increases the production rate but, reduces the comber noil and deteriorates the quality. However, % noil and feed rate relationship is different for forward and backward feed systems and will be explained later. Feed distance also very much depends upon the staple length. Fig Cm-5 indicates typical values of feed distance for different length of cotton fibre.



Typical values of feed distance per cycle;

A: feed distance (mm) per cycle per feed; B: staple length of cotton

Fig Cm-5

Feed type:- Feeding can take place when the nippers move backwards (known as backward feed or counter-feed) and alternatively, when nippers move forward (known as forward feed or concurrent feed) during a combing cycle. Counter-feed is used when better quality of product is required at the loss of more noil (12-25%). Concurrent feed is preferred when higher production rate with less noil desired (5-12%). Details of this will be discussed later.

Detachment setting:- This is one of the main settings responsible for the change of noil percentage. This setting refers to the distance between the bite of the nippers and the nip of the detaching rollers when nipper assembly is at the most advance position. A closer

setting is associated with lower noil level. Detachment setting normally lies in the range of 15-25 mm. A large setting (more than optimum) does not produce further improvement in quality, but results in more loss of noil. As such, optimum setting has to be found out depending on quality and production level desired for a particular machine and material processed.

Number of points on the comb:- Saw tooth clothing is used in circular comb and needles are used in top comb. Fineness and point density depend on the raw material processed. Usually top comb point density falls in the range 23-32 needles per centimeter. More needles give more noils.

Depth of penetration of top comb:- Lowering of the top comb by about 0.5 mm is followed by an increase in noil of about 2%. The main improvement is seen in elimination of neps. Over deep penetration of the top comb disturbs fibre movement during piecing and so optimum penetration is very important.

Piecing and detachment timing:- During piecing, fibre fringes are laid on top of each other in the same way as roofing tiles. Sliver produced in this way has a wave like structure due to this piecing having a wavelength of 30-75 cm. This is known as piecing defect. The combed fibre fringes can be compared with very flat parallelogram although the leading edge is blunter. By using correct setting (by adjusting the timing when detaching begins relative to the instant at which the fringe protruding from the nipper reaches the nip line of the detaching rollers), it is possible to lay the fringes on each other in such a way that unevenness in successive fringes partly cancels out. On the other hand, incorrect settings will cause an increase in unevenness arising from piecing.

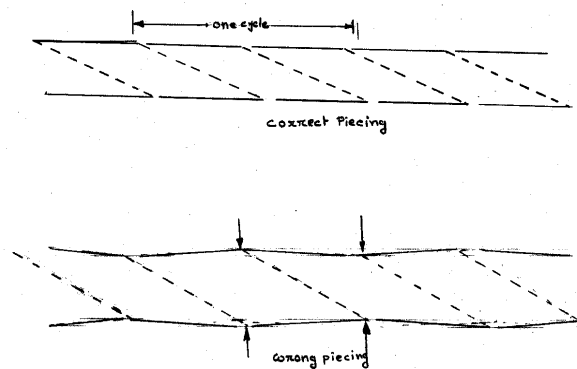


FIG. CM-6

MATERIAL PREPARATION FOR COMBING

Parallelization of the feed fibres:-

Parallelization of the feed fibres depends upon the draft between card and the combing machine. If the fibres are not oriented (parallelized), then long fibres are presented to the circular comb as if they are short fibres (as shown in Fig Cm-7) and they are therefore eliminated as noil.

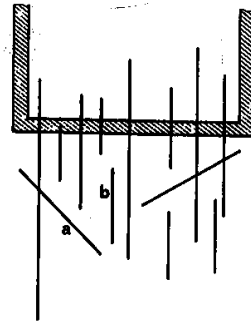
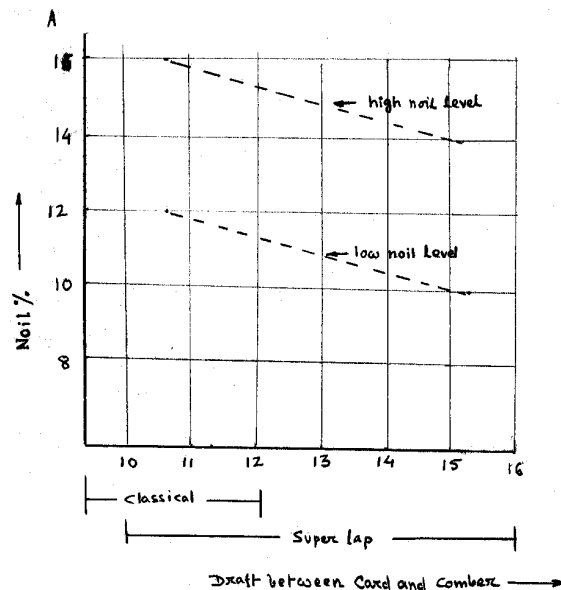


Fig Cm-7

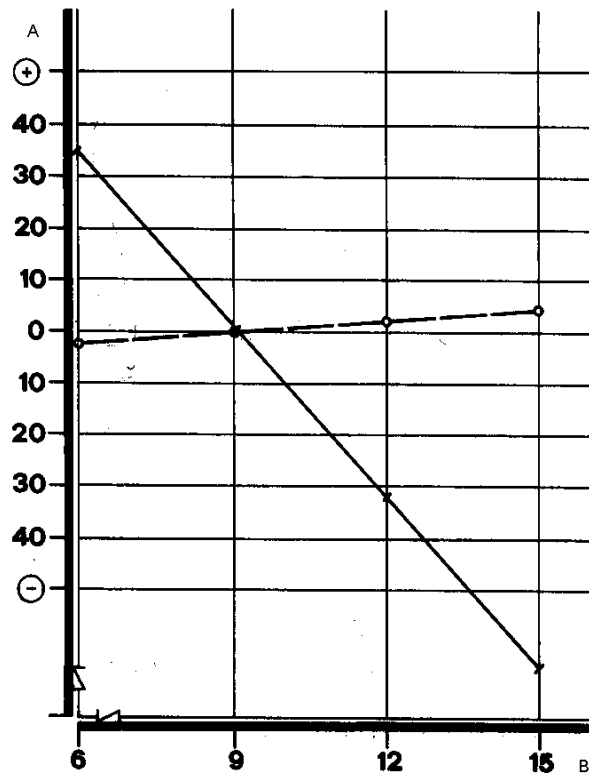
Therefore, noil level decreases with increase in parallelization of the feed fibres. However, after a certain stage, it does not necessarily affect the quality of the yarn produced. Fig cm-8 shows the reduction in noil vs draft between card and combing at fixed settings in the combing machine.



A: noil percentage; B: draft between card and comber

FigCm-8

At the same time, too high parallelization is also not desired. During detaching, a few fibres reaching the nip of the detaching rollers are drawn out of the thick layer of feedstock. During this step, impurities and neps remain in the sheet because of the retaining power of thick layer. This retaining power and hence the self cleaning effect of the sheet, will be greater, the more random is the disposition of the fibres in the sheet. Therefore, in a very parallel order, neps are no longer held back and some of the neps and impurities pass through the top comb and so cleanness of yarn is affected. Fig Cm-9 shows a relationship between draft between the card and the comber (indicating degree of parallelization) Vs cleanness and also strength at constant settings in combing.

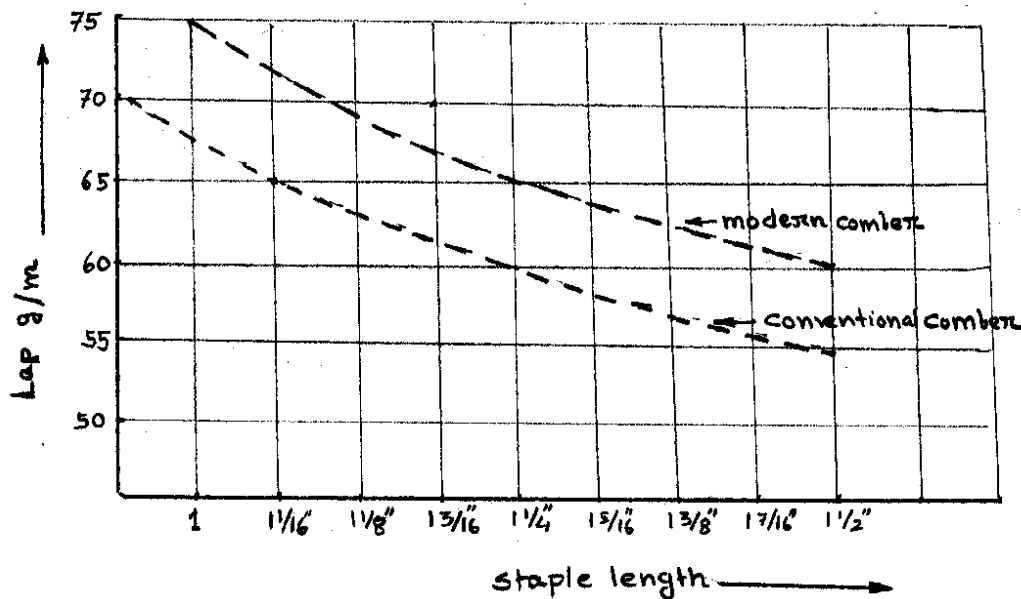


A: percentage change; B: draft between carding and combing

Fig Cm-9

Sheet thickness

Apart from parallelization, thickness of the sheet also exerts influence on retaining power. Moreover, some thickness is desired to have a good nipping action during combing. In addition, a thicker sheet gives more production. However, too thick a sheet results in overloading the circular comb resulting in poor efficiency of combing action. The ideal sheet fineness normally lies between 55 and 75 ktex (g/m). Typical values for different fibre length are presented in Fig Cm-10



A: fineness of lap; B: staple length;

I comb of previous generation; II: comb of present generation

Fig Cm-10

Evenness of the Lap sheet:-

Slivers are not fed directly to a combing machine since the nipping by nippers would occur only on the high points(Fig Cm11); this would result in clumps of fibres being pulled out during combing. Therefore, laps are prepared using preparatory machines such as sliver lap and ribbon lap machines and these laps are feed to the combing machine. Sufficient doublings are required during the preparation of the laps so as to

produce laps with good uniformity. An even lap across the width gives a better clamping by nippers.

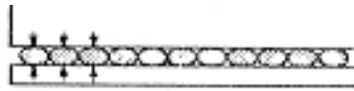


Fig Cm11

Disposition of hooks

Fibres must be presented to the comber with majority of the hooks as leading hooks. These hooks are then removed by the circular comb. If the hooks are fed as trailing hooks, then comber will assume these as short fibres, when released by nippers and as a result, % noil will increase. In an experiment conducted by Morton and Nield, it was found that by interposing another drawing operation between carding and combing, the amount of comber waste produced was increased from 13% to 18.8% but, if the extra process was accompanied by an additional reversal of sliver at some point in the process, so that the majority hooks were still presented as leading hooks to comber, the waste was only 11.45%. Thus, an additional drawing process prior to combing does give rise to more parallel fibres and fewer hooks, but this is more than offset by the presentation of majority hooks in the combing direction unless this is specially overcome by a specially arranged reversal. So, there should be an even number of processes between carding and combing with normal reversal.

Both the quantity and the form of the hooks depend mainly upon the stiffness of fibres. This rises to the second power with fibre fineness. More numbers and longer hooks are produced while processing fine fibres.

THE NOIL THEORY OF GEGAUFF

The feed by the feed rollers can be made while the nipper assembly moves forward or backward. Accordingly, they are called forward feed and counter feed in combing.

IN BACKWARD FEED (ALSO KNOWN AS COUNTER-CURRENT FEED).

During counter-current feed, any fibre longer than detachment setting E (distance between the nipper and the nip of the detaching rollers when the nipper is at the most forward position) is detached by the detaching rollers.

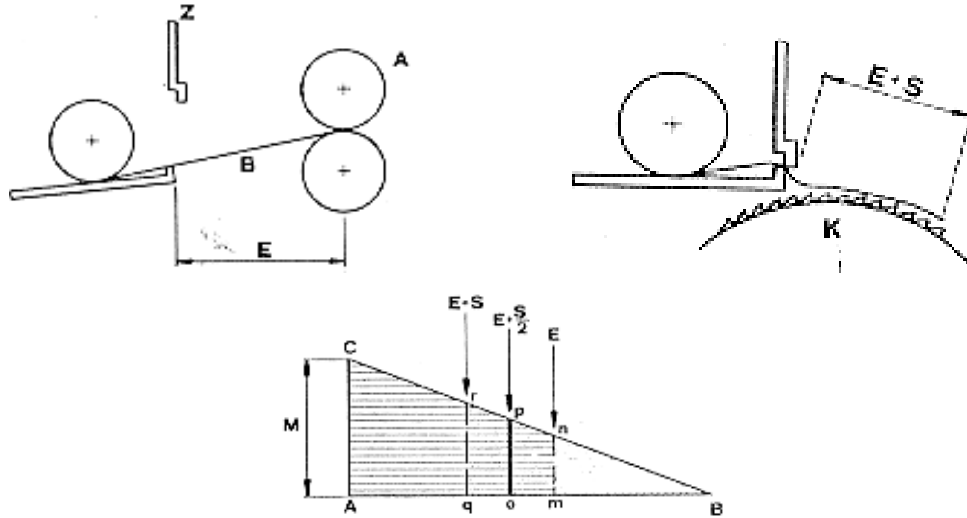


Fig cm-12

The fibre length diagram of cotton is shown in the fig Cm-12. For easy theoretical explanation, this diagram is modified from the actual diagram.

When the nippers move back, feed rollers feed the sheet a distance 'S'. So the fringe projecting from the nippers is now presented to the circular comb with a length "E+ S". All the fibres shorter than "E + S" are carried away by the circular comb and will be eliminated.

As seen in the diagram, those fibres lie in the area between "q" and "m" therefore may or may not be removed during combing. Accordingly, a division can be made based on the mean fibre length within this area, which in "E+ S/2". Any fibre shorter than this can be considered as combed and therefore goes as noil.

From the similar triangles,

$$\frac{\nabla OBP}{\nabla ABC} = \frac{OP^2}{AC^2}$$

Area represents the weight of fibres, and noil % is based on weight.

Therefore,

$$\% \text{ Noil} = \frac{\nabla OBP}{\nabla ABC} = \frac{OP^2}{AC^2} \times 100$$

$$= \frac{(E + \frac{S}{2})^2}{M^2} \times 100$$

IN FORWARD FEED (ALSO KNOW AS CONCURRENT FEED)

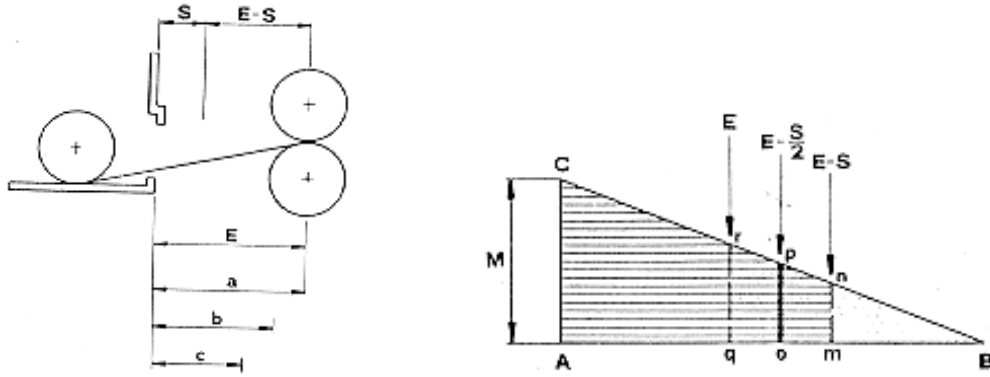


Fig Cm-13

In this case, there is no feed during the return of the nippers. So, any fibre shorter than E will be removed by the circular comb, because the projected length of the nipped fringe is "E". Feed occurs during subsequent forward movement of the nippers and so fringe length is increased by "S" ("S" is the feed per cycle). Therefore, it is expected that any fibre longer than "E-S" will be nipped by the detaching rollers and will go to the combed sliver; trapezium 'AmnC' represents these fibres (Fig Cm-13).

$$\text{In this case, noil \%} = \frac{\nabla OBP}{\nabla ABC} \times 100$$

$$= \frac{OP^2}{AC^2} \times 100$$

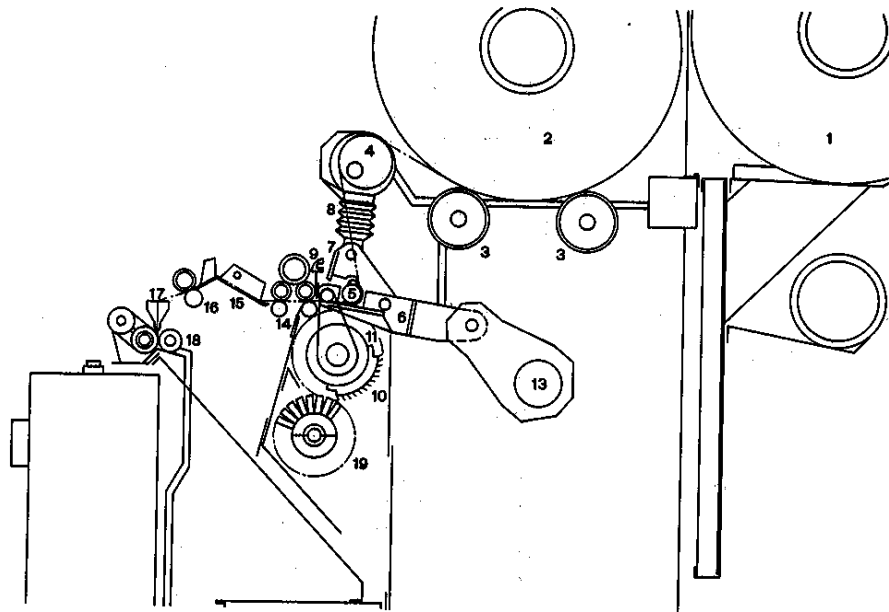
$$= \frac{(E - \frac{S}{2})^2}{M^2} \times 100$$

From these derived relations, it follows that where counter-current feed is used, noil is increased as feed distance is raised, whereas, in concurrent feeding, noil is reduced as the feed distance is increased. In general, there will be more noil in counter-current feeding.

It is better to work with backward feed than forward feed for the same waste %. Nep removal will be better because top comb penetrates into the fibres which are already combed by the circular comb. Moreover, loss of longer fibres in the waste will be less. The detaching distance will be less for the same waste % compared to forward feed. Therefore, fibre control during detaching and top comb penetration will be better. Also with backward feed, the circular comb penetrates into the fibre fringe more often than in the case of forward feed. Therefore, the quality of combing operation is increased in backward feed.

DESCRIPTION OF SOME PARTS OF COMBING MACHINE

Rieter E 7/5 rectilinear single sided machine is used as a reference for describing some important components of combing machine. Fig Cm-14 shows the cross section of the Rieter machine.



1. Reserve lap; 2. Lap; 3. Lap support roll; 4. Eccentric shaft; 5. Feed roller; 6. Nipper; 7. Nipper top plate; 8. Spring; 9. Top comb; 10. Circular comb brush; 11. Circular comb; 13. Oscillating nipper shaft; 14. Detaching rollers; 15. Web pan; 16. Load off roller; 17. Trumpet; 18. Table roller

Fig Cm-14

FEEDING

Lap is unrolled by the rotation of the fluted roller (3 in Fig Cm-14). The sheet is fed over the eccentric shaft 4; this eccentric shaft is rotated intermittently forward and backward in sequence with the nipper cycle. As the nipper assembly with the feed rollers moves forward and backward, the distance between the fluted lap rollers and the feed rollers increases and decreases. The eccentric shaft compensates these changes and keeps the lap at a constant tension.

NIPPER ASSEMBLY

The design of the nipper assembly (Fig Cm-15) is of enormous importance for a high speed comb. The mass must be low, since nipper is accelerated and decelerated back to rest twice per cycle(up to 16 times per second in a high speed machine). In order to reduce the mass, aluminum nipper assembly is used in modern combers. However, in order to provide a strong nipping action on a thick lap sheet (up to 80 ktex), the nipper plates are made of steel. The upper nipper plate is stiff while the lower one is slightly springy. Two springs (5), one on each side of the assembly, generate the required contact pressure on closing. The design of the nose is shown in Fig Cm-16. This design helps to prevent fringes coming out during combing.

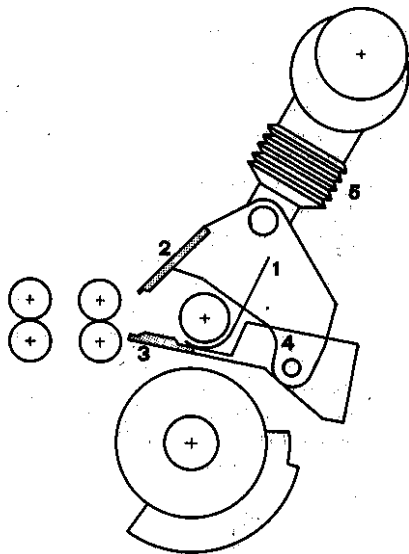


Fig Cm-15

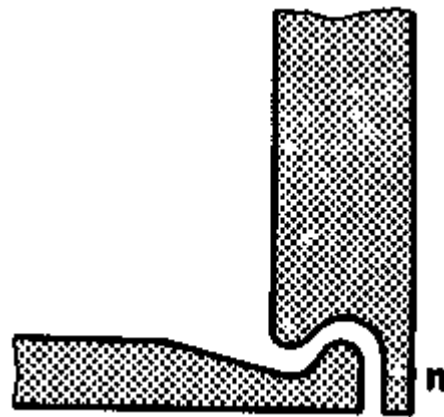


Fig Cm-16

As shown in Fig Cm-17, the swing of the nipper assembly is controlled by the rotation of the nipper shaft (1) and circular comb shaft (7) through levers 6 and swing arm 2. The top

nipper plate is connected to the bottom nipper plate. The top nipper plate is also suspended from the shaft (12) through spring (11). As the nipper is moved forward, the upper lever is raised relative to the lower nipper owing to the difference in leverage and as a result nippers are opened. As the nippers are withdrawn, the spring presses the upper nipper back against the lower nipper.

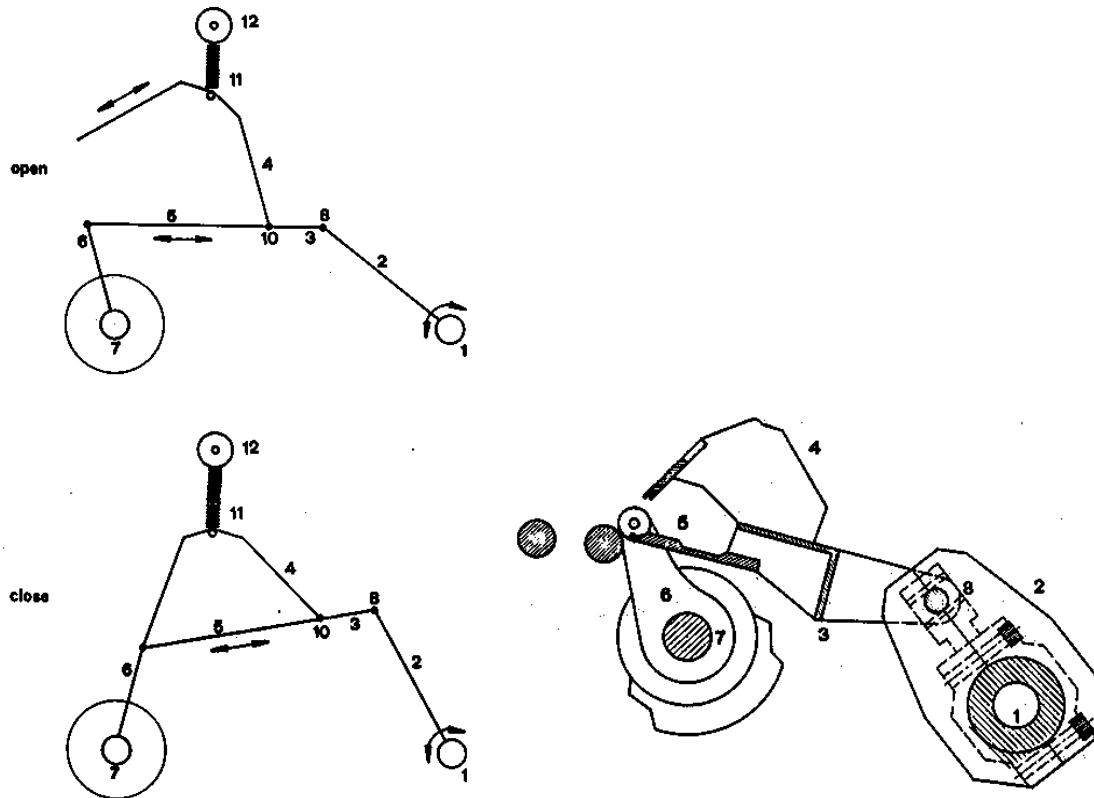


Fig Cm-17

CIRCULAR COMB:

The cylinder drive shaft (R) extends through the whole machine and carries one combing cylinder (C) in each head. The combing segment may have needles or metallic clothing as shown in Fig Cm-18.

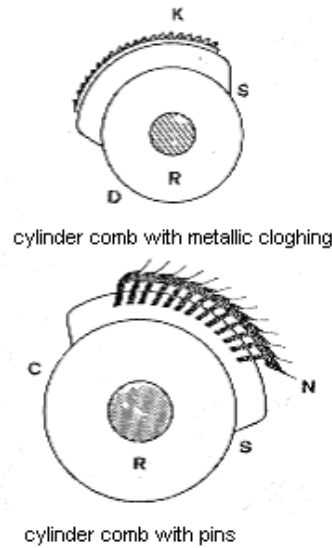


Fig Cm-18

Since metallic clothings are more robust, they are not liable to get damaged easily. Therefore, such clothings require less maintenance and hence, used in almost all high production machines. In the case of needles, 14-18 rows are present with progressively finer needle density from first to the last row. Similarly, in metallic clothing also, coarser to finer zones of point density are provided; coarse zone comb at the start, with somewhat finer zone at the middle and highest density zone comb towards the end. Circumference with wire points are usually 75° , 90° , 110° in different machines.

TOP COMB (FIG CM-19)

The top comb has a holder (H) to which the needle bar (B) is secured by screws. The needles are soldered to the bar.

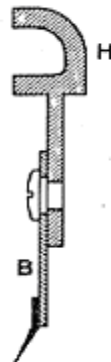


Fig Cm-19

The top comb is connected to the nipper assembly and so swings along with nippers. During the forward swing, the top comb penetrates through the fibre fringe and on its reverse movement comes out. It is not subjected to any up and down movement. Apart from the depth of penetration, top comb spacing from the detaching rollers is also important and can be adjusted.

For a micronaire of less than 3.6, needles per centimeter is usually 30. For a micronaire of more than 3.8, it can be less, usually 26.

Top comb plays a major role in waste removal. Out of total comber noil, about 60% is removed with the assistance of the top comb. However, top comb gets damaged soon. Even 4-5 damaged needles affect the quality seriously. Therefore top comb maintenance is very important in combing.

Given a chance, it is better to remove waste more by more top comb penetration as far as possible than increasing the waste by increasing the detaching distance. When detaching distance is more, control over detaching is less

PIECING

Detaching rollers perform a back and forth movement in order to piece up the newly combed web with the web combed and detached in the previous cycle. The forward component (V) is larger than the backward component (R) as shown in the Fig Cm-20. This is required so that an effective take off (A) is achieved. In Rieter E 7/5 comber, the relevant movements are

$$V=81\text{mm}$$

$$R=49.5\text{mm}$$

$$A=31.5\text{ mm}$$

The constant basic rotation of the detaching rollers (B) is given from the comb shaft. An intermittent rotation (A) is superimposed on this basic rotation. The net forward movement is thus $A+B$ and net backward movement is $-A+B$; thus, $C = -A+B$. Since C is negative, it gives a reverse movement to the detaching rollers.

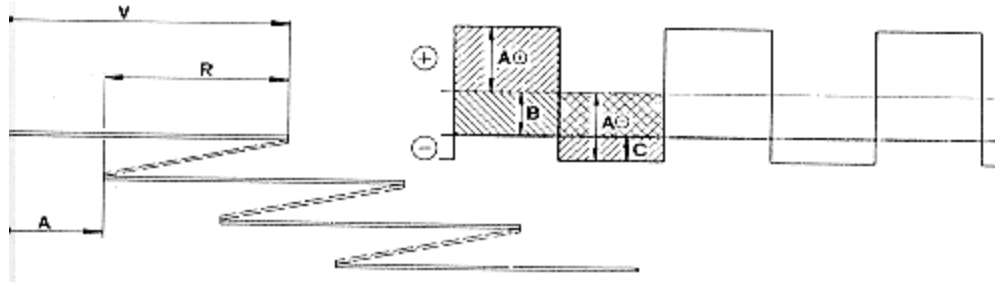


Fig Cm-20

FORMATION OF SLIVER

The detaching rollers forward the pieced up web periodically. However, the same material must be condensed through the trumpet into a sliver and withdrawn continuously. So, a reserve of material must be formed periodically between the detaching cylinder 'R' and the withdrawing roller 'Z'. The web pan 'V' functions as a web reservoir. During forward movement of the detaching rollers, the corrugated sheet is formed on this pan and during the reverse rotation of detaching rollers, the web sheet is straightened.

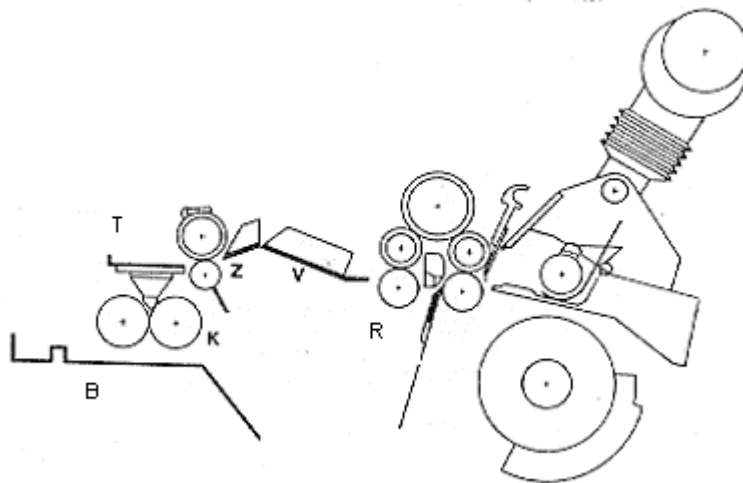


Fig Cm-21

The web is passed through the trumpet as shown in Fig Cm-22.

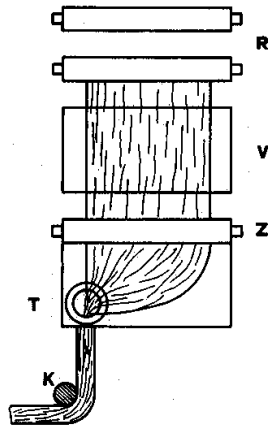


Fig Cm-22

The side collection places the piecing lines diagonally in the sliver, which means that piecing defects will get distributed and the amplitude is reduced.

The slivers from the individual head come out and take a 90° turn in the common sliver table as shown in Fig Cm-23 and moves towards the drafting arrangement. The distance traveled up to the drafting point can be varied by adjusting at the turning point so that the piecing points of slivers can be shifted relative to each other.

The drafting arrangement provides the required draft to the assembled slivers from heads and produces the final sliver.

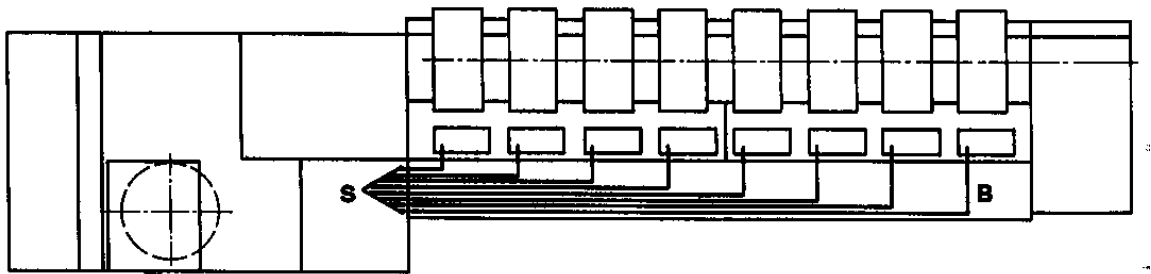
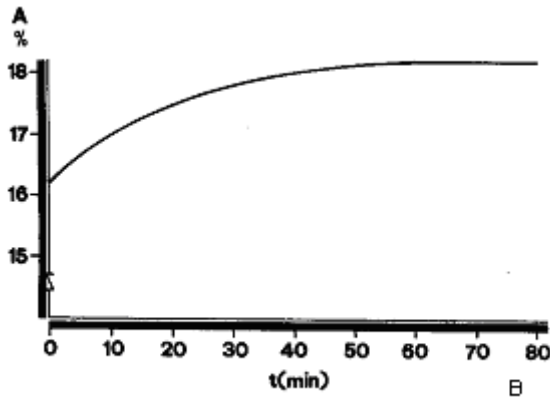


Fig Cm-23

WASTE REMOVAL:

In combing, if circular comb is not cleaned properly, then it gets loaded and combing suffers. In all modern combers, the combing cycle is slowed down (to 1/5th of normal speed) at preset intervals for better cleaning purpose. The brush below the circular comb continues to rotate at full speed and thereby cleans the comb effectively when the cycle

speed is reduced. Fig Cm-24 shows the increase in the level of noil with un-interrupted full speed running and Fig Cm-25 shows noil level in periodic cycle when machine speed is reduced periodically.



A: % noil ; B: running time

Fig Cm-24

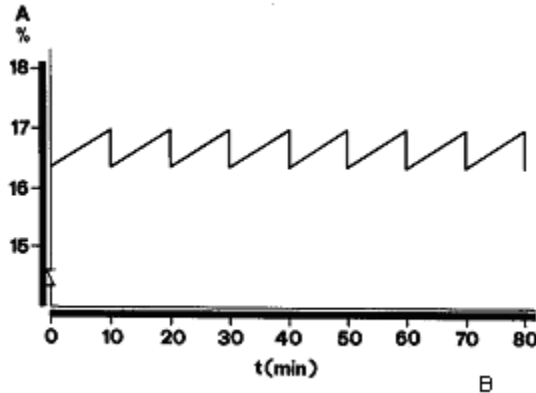


Fig Cm-25

Since, initially comb is clean, the noil gets caught in the comb and the cleaning brush cannot remove them and therefore, % noil is initially low and subsequently increases.

COMBING PRODUCTION:

From the discussion on various issues connected with combing cycle, it can be clearly understood that combing production depends on the following factors:

- N-nips per minute
- S-feed in mm per minute
- G- lap weight in g/m
- K-noil percentage
- A-tension draft between lap roller and feed roller(usually 1.05-1.1)
- E-%efficiency of the machine

$$\text{Production in kg/hour} = \frac{E \times N \times S \times G \times (100 - K) \times 60}{1000 \times 1000 \times A \times 100}$$

The following production data is provided from the Rieter literature for its latest generation combing machine.

Concept of draft and production with an example

Let us say,

Linear density of lap feed = 80 ktex

Number of heads in the combing machine=8

% Noil= 15%

Total mechanical draft=80 (Mechanical draft indicates surface ratio between final sliver deliver speed over lap feeding speed by lap roller)

Calculation of Linear Density of the Delivered Sliver

Since 8 slivers produced in each head will be combined to one,

$$\text{Linear Density of delivered Sliver} = \frac{\text{Linear Density of the Feed of 8 Laps Together}}{\text{Actual Draft}}$$

$$\begin{aligned} \text{But, Actual draft} &= \frac{\text{Mechanical Draft}}{100 - \% \text{Noil}} \times 100 \\ &= \frac{90}{100 - 15} \times 100 = 105.8 \end{aligned}$$

$$\text{So Linear Density of the delivered sliver} = \frac{8 \times 80}{105.8}$$

$$= 6.05$$

LAP PREPARATION FOR COMBING

The requirement of lap of proper thickness for good performance in combing has already been discussed. It is clear that lap should be prepared in such a way that

- Fibres are parallel
- Majority of hooks are present as leading hooks
- Lap should be uniform in thickness

In addition, the lap preparation should ensure

- Lap with less number of piecing points
- Lap without tendency of licking
- Lap with longer length (bigger laps)

Every piecing is a defect. Therefore there should be less number of piecing in combing. This is ensured with a bigger lap. Moreover during preparation, lap piecing can be avoided if super lap machines are used instead of traditional sliver lap and ribbon lap former.

Any one of the following two sequences is used for preparing the lap for combing:

- Sliver lap machine followed by a ribbon lap machine
- Draw frame followed by a super lap former(also known as sliver doubling)

Sliver and Ribbon lap machines

In the first case, a number of slivers are doubled and drafted together to form laps in sliver lap machine. These laps are then again doubled by unrolling them one over the other and then drafted to form the final lap in the ribbon lap machine. The side by side blending of slivers in the first process and overlapping in the second ensure adequate uniformity in the final lap. However, in the ribbon lap machine, whenever a lap is exhausted, a new one is joined to feed the same number of laps resulting in a piecing defect.

Super lap machine (Sliver blending)

Here, both the operations of side by side blending and overlap blending are carried out in the same machine. Therefore a large number of slivers (28 or even more) are used and more draft is provided in a single operation. Any piecing required during breakage of slivers or exhausting a sliver does not result in fault as big as lap piecing. Since the number of processes between the card and the comber should be of even number and more parallel fibre in lap is desired, a draw frame passage is required before feeding the carded sliver into a super lap machine.

In modern combing rooms, lap preparation is invariably carried by the super lap machine. The Fig.Cm-26 provides a view of sliver doubling in a super lap machine of Marzoli.

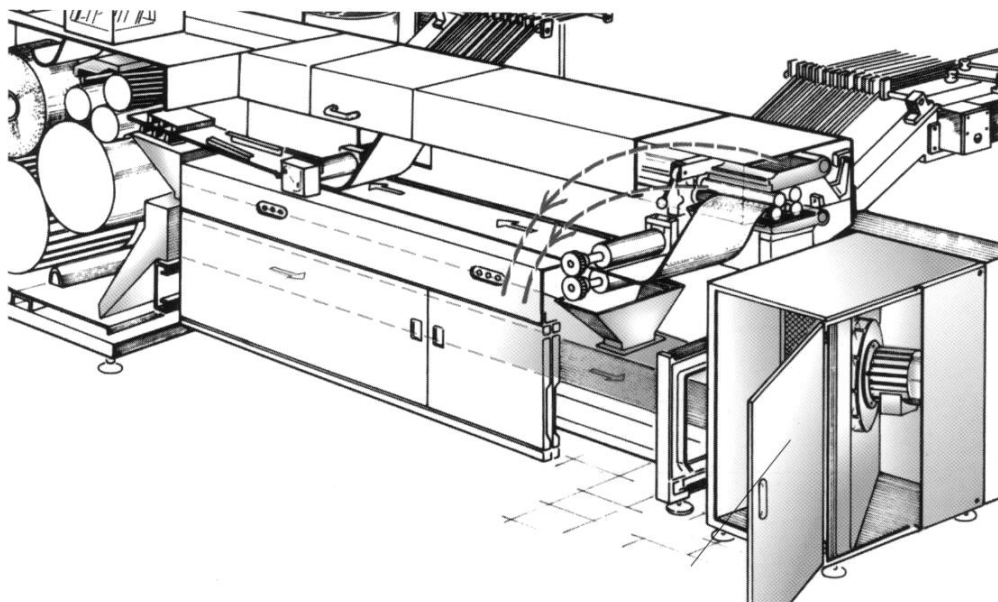


Fig.Cm-26

The following are some information about modern lap preparation and combing machines.

UNIlap of Rieter (Super lap machine)

<i>Cotton</i>	<i>Lap Liner Density in Ktex</i>	<i>Lap weight(Kg)</i>	<i>Delivery m/min</i>
1"	80	19	90
1 1/16"	75	20	90
1 1/8"	75	22	90
1 1/4"	75	25	100
1 1/2"	75	25	100

Efficiency %: 73-74

Combing machine

<i>Cotton</i>	<i>Nips/min</i>	<i>Noil %</i>	<i>Production kg/hr</i>
1"	350	14	63
1 1/16"	350	16	58
1 1/8"	350	16	51

1 ¼"	325	18	39
1 ½"	325	20	35

Efficiency % : 91-92

Latest models of machines for example, E 72 of Rieter can operate at speeds up to 400 nips/minute working with efficiency up to 96% giving a production up to 60 kg/hour. In most of the modern combing rooms, automatic transfer of laps from preparation to comber is done. Production of modern preparation machines is up to 350 kg lap per hour

TEST YOUR UNDERSTANDING

- List out the factors on which % noil in combing depends.
- What are the factors a spinner should look into to decide % noil in combing?
- What are the improvements of yarn properties anticipated after combing?
- In case of polyester/ cotton yarn, what type of process sequence would you recommend from blow room up to ring frame including combing?
- How do you expect the following parameter to be changed after combing
 - UHML
 - 2.5% and 50% span length
 - Effective length
 - Micronaire value
 - Bundle strength
- List out important settings in order of priority to get the maximum combing efficiency.
- How are % feed and combing performance interrelated for forward and backward feeding systems in a combing machine?
- List out the important parameters to be looked into in order to control the piecing defects in a combing machine.
- Try to explain various parameters in the comber lap that effect
 - Quality of combed sliver
 - Loss of good fibre with noil

- Production and efficiency of combing machine
- Compare the salient features of a nipper assembly of a modern high speed combing machine.
- Compare the relative merits and demerits of backward and forward feeding system.

TRY TO FIND OUT

- How timing of different actions in a rectilinear comber is set with the help of index wheel in a combing machine you have come across.
- How does a factory utilize combed noil.
- Following parameters for a given % noil in the combing machine you have come across.
 - Feed distance and the fibre length
 - Feed type
 - Detachment setting
 - Wire density in circular and top combs
- The additional cost of production for manufacturing the same count with combing over a sequence not having combing for a given % noil in the factory.
- The motion transmission to the detaching roller. What is the mechanism of achieving forward and reverse movement in detaching rollers?
- The production and efficiency of the combing machine and also the combing efficiency in the combing shed in the factory.
- Major reasons of stoppages of combing machine.
- Type of lap preparation sequence available in the factory.
- Machine details of both combing preparation machines and combing machine such as, number of heads, nipper speed, drawing roller arrangements, lap weight, lap diameter, drafts, type of stop motions etc.