TXL 221: Yarn Manufacture I

3 Credits

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Marks Distribution

Minor:	**40**
Quiz :	**20**
Major:	**40**

Attendance Policy

- **Minimum Attendance** : **75%**
- **Attendance less than 75%** : **One grade down**
- **Attendance more than 95%** : **5 bonus marks will be added to the final marks.**
- **Late attendance** : **Will be marked as absent after attendance has been already registered.**

Course Outline (Lecture)

Opening/Blowroom:

- ✓ **Principle of fibre opening in blow room**
- ✓ **Principle of fibre cleaning in blow room**
- ✓ **Opening and cleaning machines**
- ✓ **Principle of fibre blending**
- ✓ **Recent developments**

Course Outline (Lecture)

Carding:

- **Objective and principle of carding**
- **Machine elements and operations**
- **Sliver formation and fibre configurations in sliver**
- **Automation and recent developments**

Course Outline (Lecture)

Drafting/Drawframe:

- ✓ **Objectives, principles and methods of roller drafting.**
- ✓ **Purpose and principle of condensation of fibres.**
- ✓ **Causes of mass variation of sliver and control.**
- ✓ **Automation and recent developments in draw frames**

Reference Books

- ✓ A Practical Guide to Opening and Carding, Short-staple Spinning Series (Volume 2), By W. Klein
- ✓ A Practical Guide to Combing and Drawing, Short-staple Spinning Series (Volume 3), By W. Klein
- ✓ Fundamentals of Spun Yarn Technology By Carl A Lawrence
- ✓ Handbook of Yarn Production-Technology, Science and Economics By Peter R. Lord
- ✓ Spun Yarn Technology By Eric Oxtoby
- ✓ NPTEL lecture series, IIT Delhi

Introduction

What is a yarn?

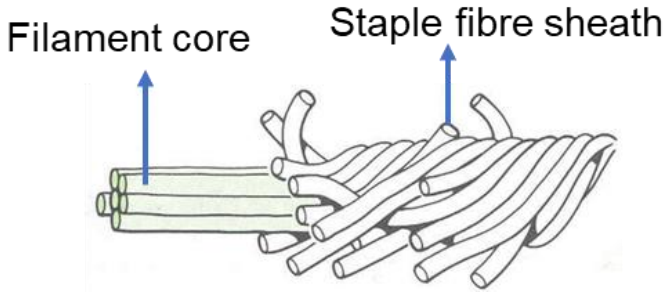
"A yarn may be defined as a product of substantial length and relatively small cross-section of fibres and/or filament(s) with or without twist, used for interlacing in processes such as knitting, weaving, or sewing"

Different Types of Yarn

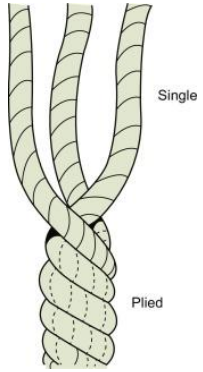
- **Continuous filament yarns**

- **Staple spun yarns**

- **Composite yarns**



- **Folded/plied/doubled yarns**



Production of Staple Yarn: Cotton and Blends

Seed fibre, cellulosic, hydrophilic

Removal of cotton fibre from seeds

Ginning process

Cotton Bale

227 kg each
0.2 g/cm^3

How to make cotton yarn from bale?

- ✓ Opening
- ✓ Cleaning why?

Impurities in Cotton Fibre

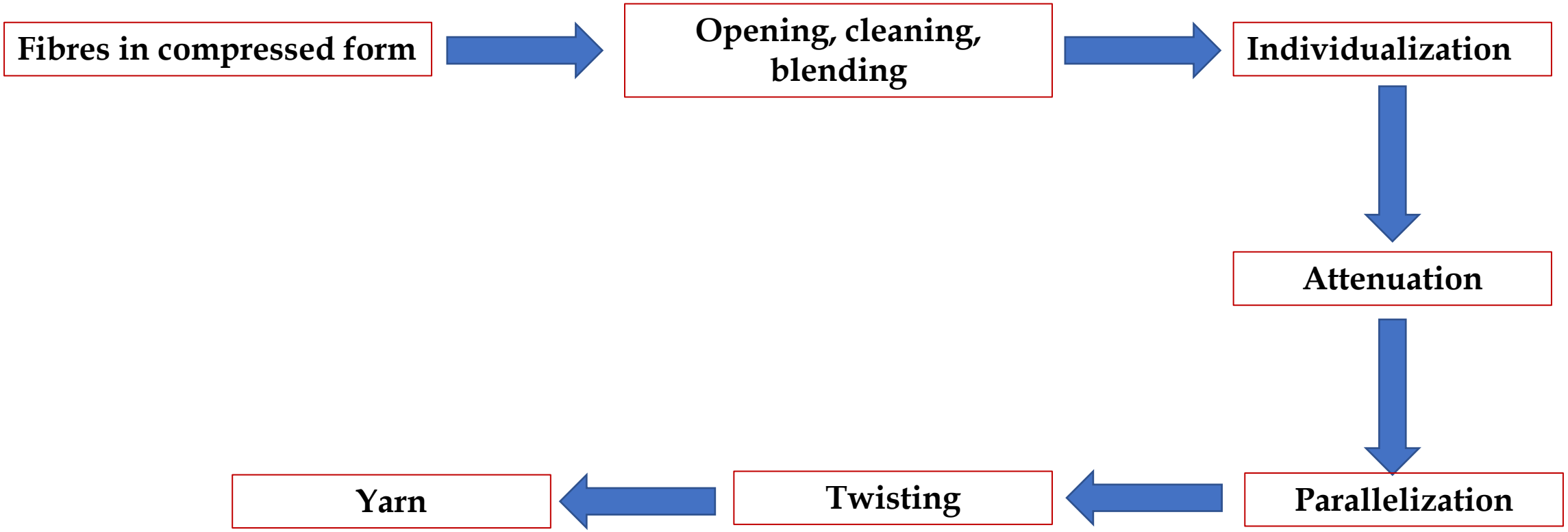
- **Vegetable matter (50-80%)**
  Seed fragments, stem fragments, leaf fragments, etc.
- **Mineral matter (10-20%)**
  Dust, sand, soil, etc.
- **Fibre fragments**
- **Others**
  Metal particles, cloth fragments, packaging materials, etc.

Trash size > 500 micron
Dust < 50 micron
Micro dust < 15 micron

Problems?

Yarn fault, damage to machines, health hazard to the workers

How staple yarns are produced?



Spinning Process Flowchart

Blow room
(Opening, cleaning, mixing, blending)

Carding
(Disentanglement & cleaning)

Drawframe
(Parallelization, straightening & reducing mass variation)

Combing
(Removal of short fibres and neps)

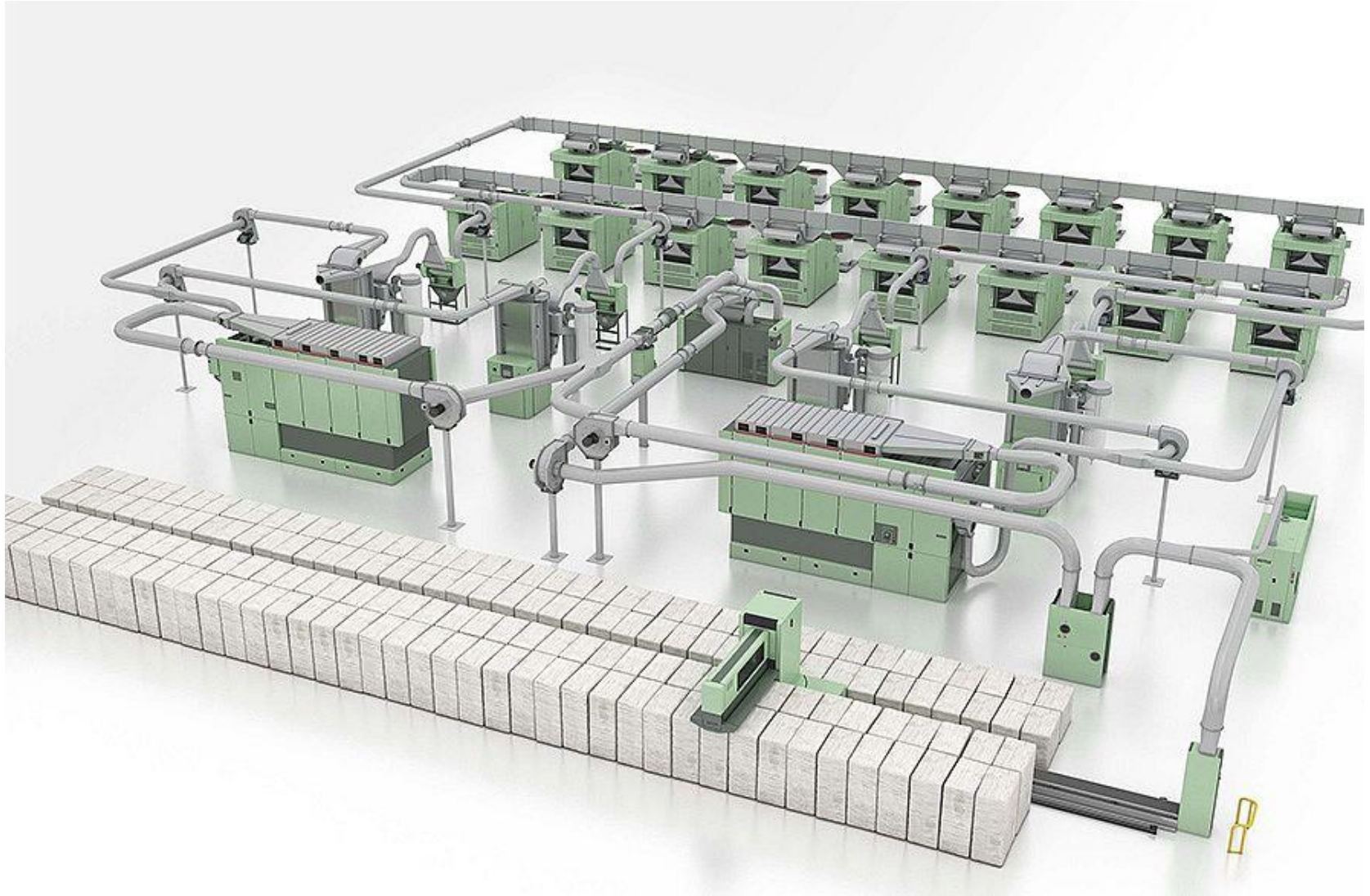
Roving Frame
(Reduction in mass per unit length)

Spinning
(Ring, rotor, vortex, air-jet spinning)

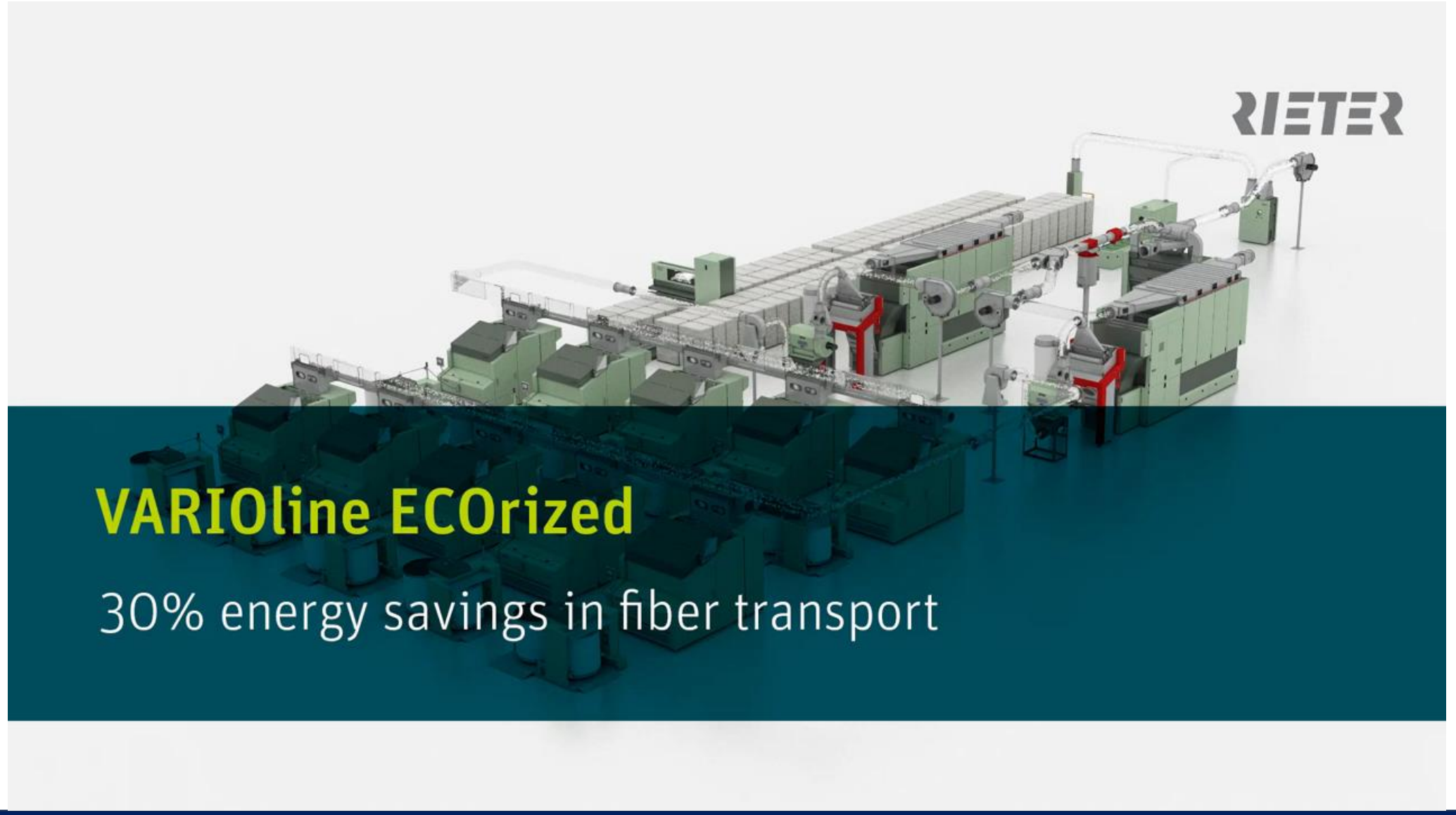
Winding
(Fault removal & packaging)

Plying
(Plied yarn)

Blowroom

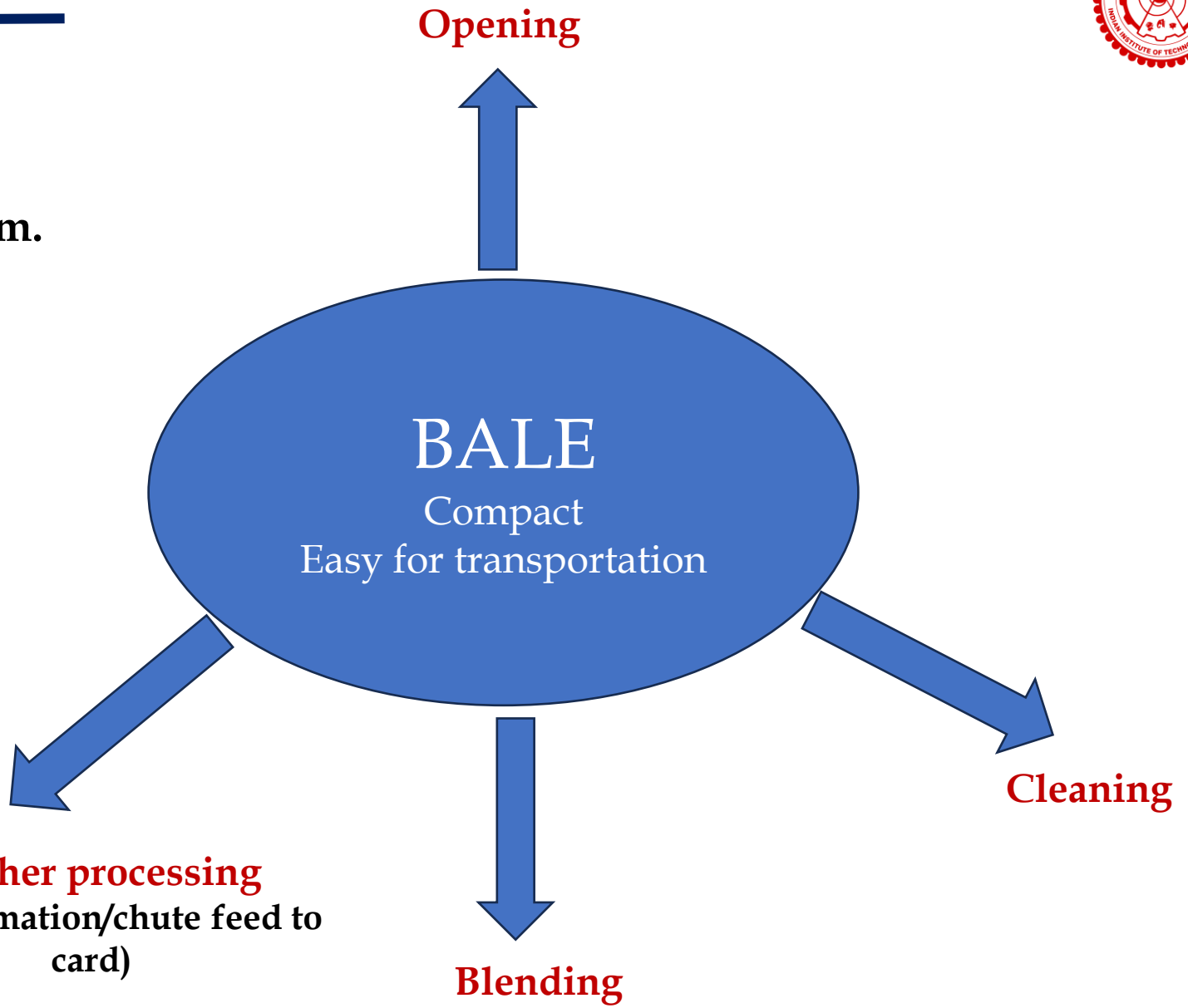


Blowroom

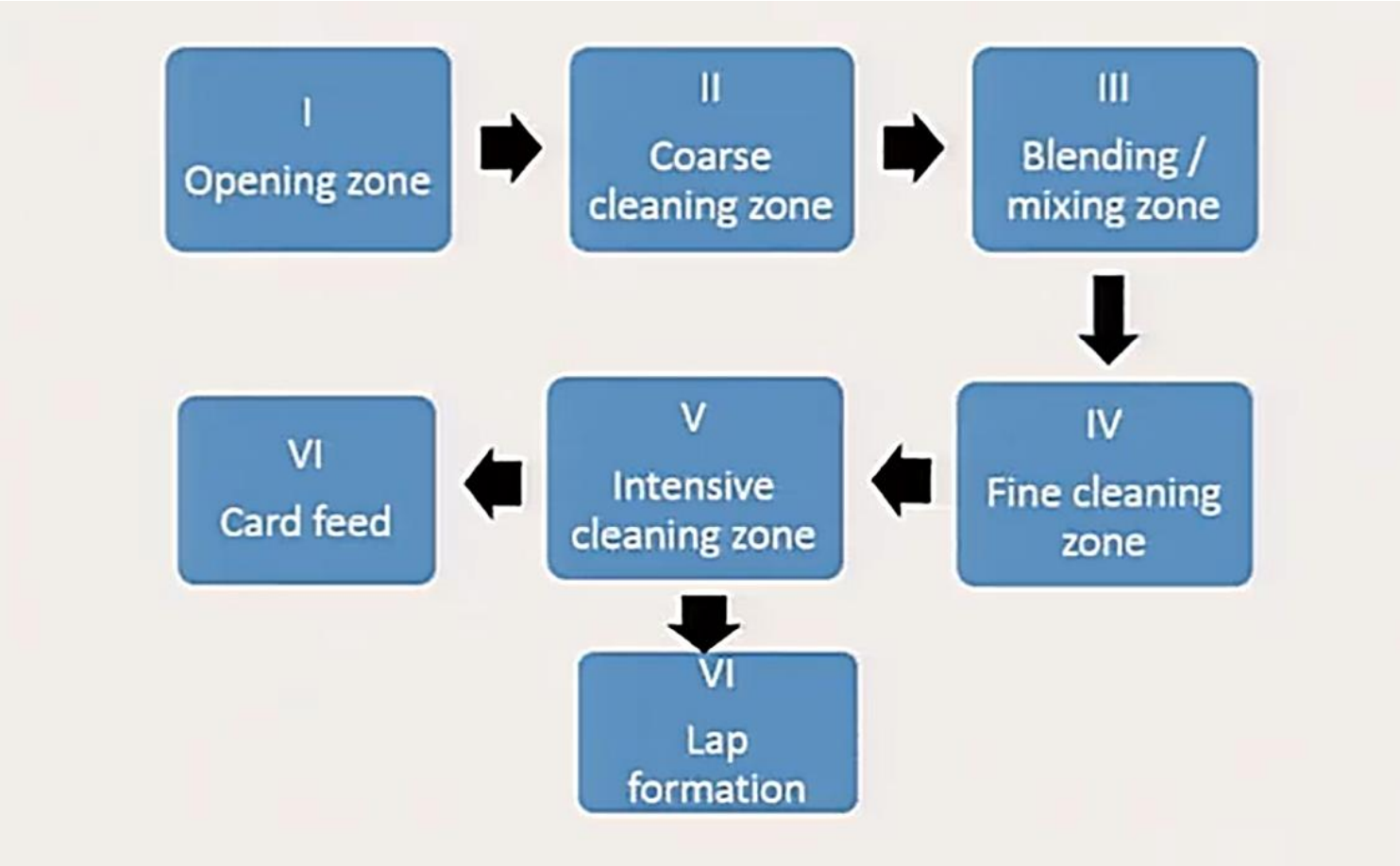

RIETER
VARIOline ECOrized
30% energy savings in fiber transport

Introduction to Blowroom

Fibres come to spinning mill in bale form.



Blowroom Operating Zones



Why Blowroom has different zones and machines?

Opening of Bale

How to open bale?

- ✓ **Removing individual fibres from bale ?**
- ✓ **Dividing and subdividing bales?**

Question: In a spinning mill, cotton fiber is supplied in compacted bales of about 226.8 kg each. The bale dimensions is typically 1.4 ×0.53×0.64 m, and the bale density is 478 kg/m^3. If the individual fibers are 30 mm in length and 1.7 dtex fineness and the production rate of the plant is 500 kg/h, then how many fibres need to be separated per second from the bale?

Ans:

No. of fibres in each bale = 45 billion (approx.)

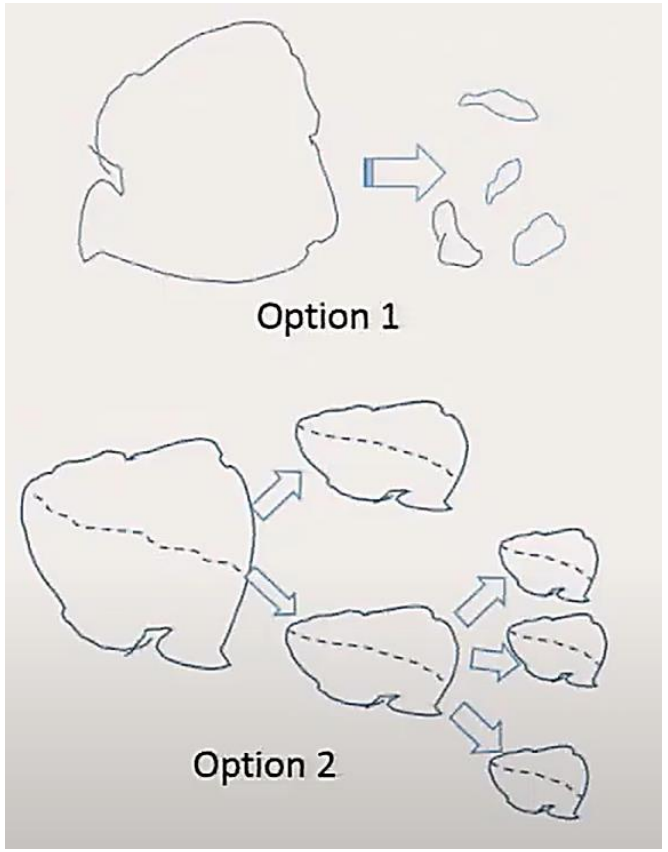
No. fibres to be separated per hour = 98 billion, 27 million fibers per second

Opening of Bale

How to open bale?

Removing large clumps of fibres from a bale

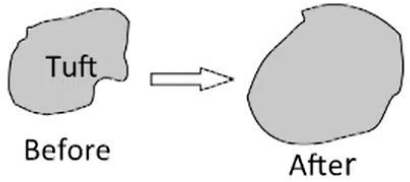
Progressively dividing the large clumps into many smaller pieces.

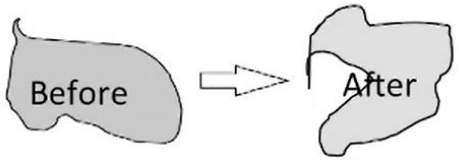


Opening of Tufts

Different Possibilities

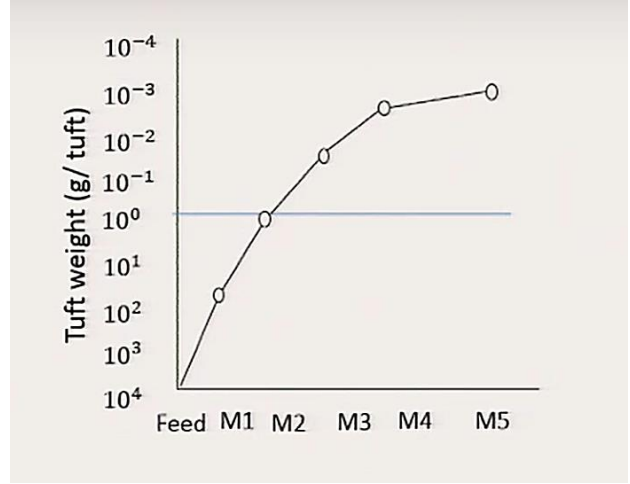
- ✓ A large tuft is divided into several smaller tufts
- ✓ Volume of tuft increases without disintegration
- ✓ Shape of the tuft changes





How to measure fibre openness?

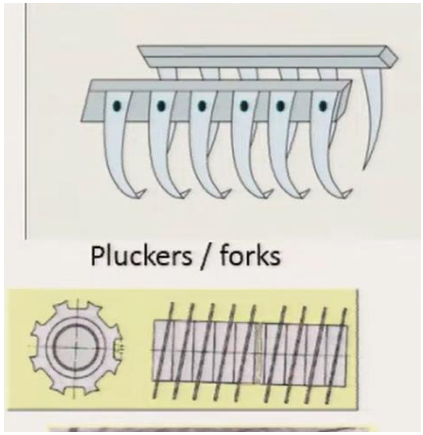
- By measuring specific volume
- By measuring tuft weight

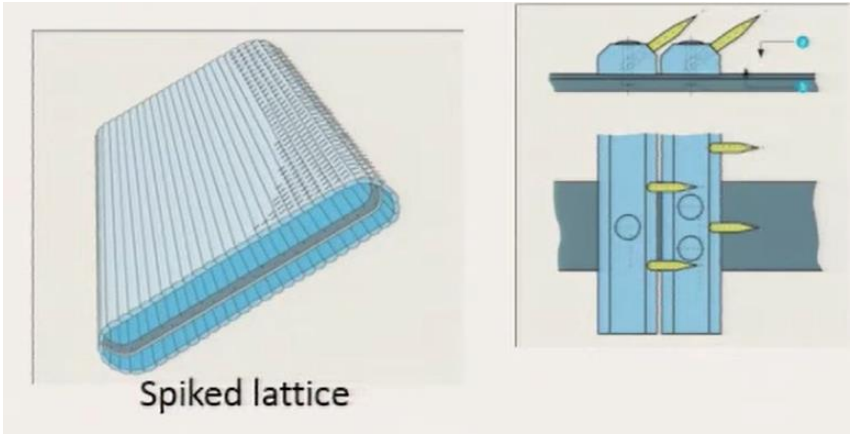


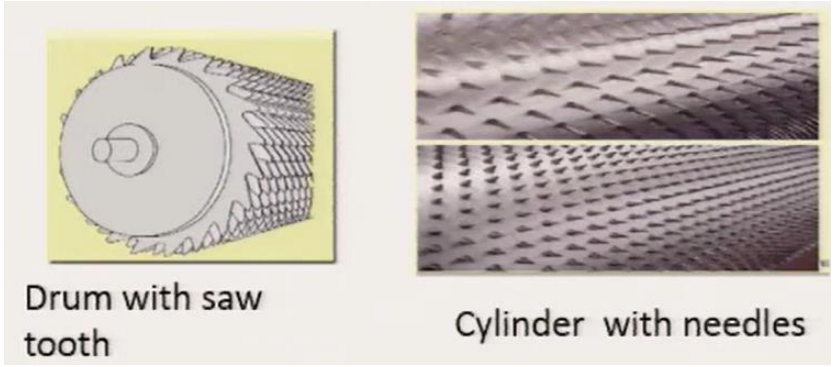
M1, M2,…blowroom machines

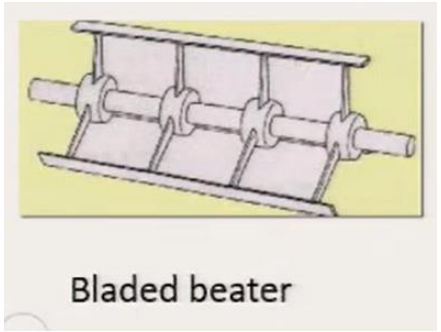
Opening of tufts: different principles

- ✓ **Plucking**
- ✓ **Tearing between oppositely moving spikes**
- ✓ **Teasing in nipped state by needles or saw tooth**
- ✓ **Using impact force at nipped state or free flight**



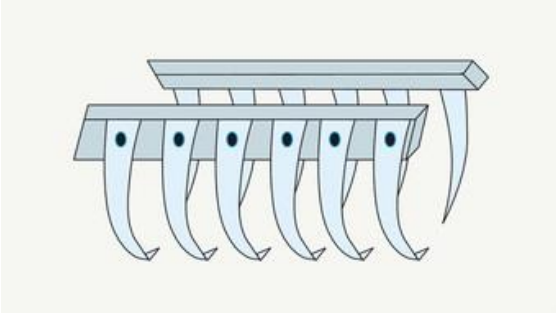






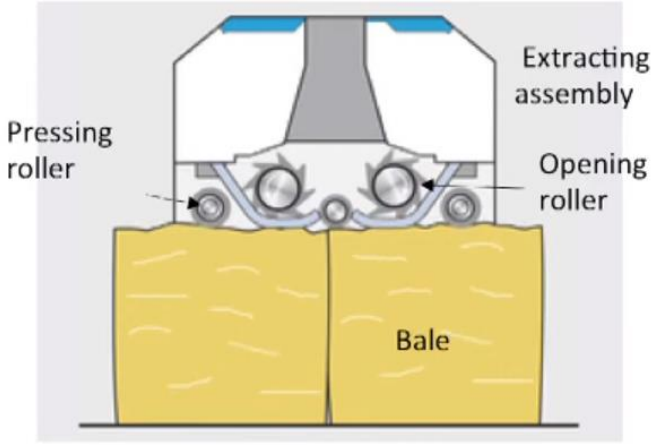
Opening of tufts: different principles

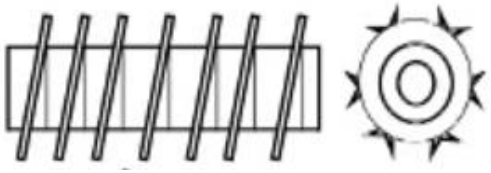
Plucking out

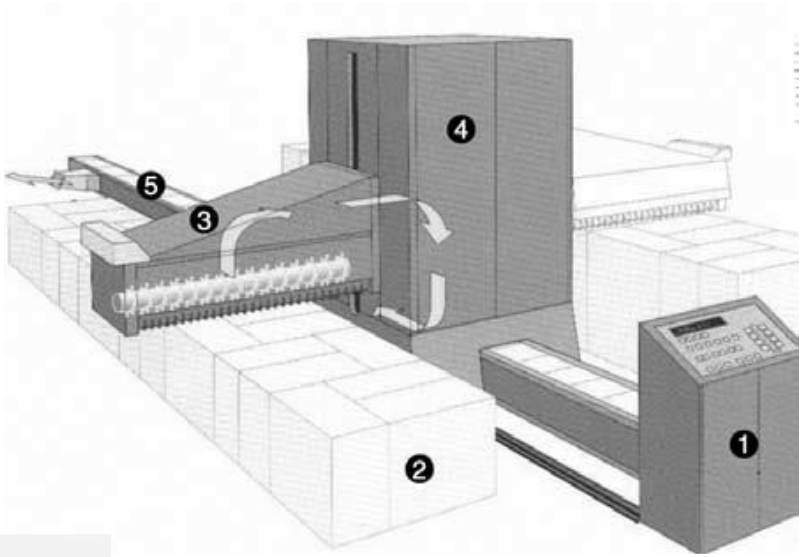


- Two spring systems facing each other.
- Material is grasped like finger
- Very gentle action
- Produces large tufts of uneven size

Forks or Plucker







Rotating discs

- ✓ Two rotating disc picks up fibre tufts from bale surface
- ✓ Tuft size: 30-80 mg

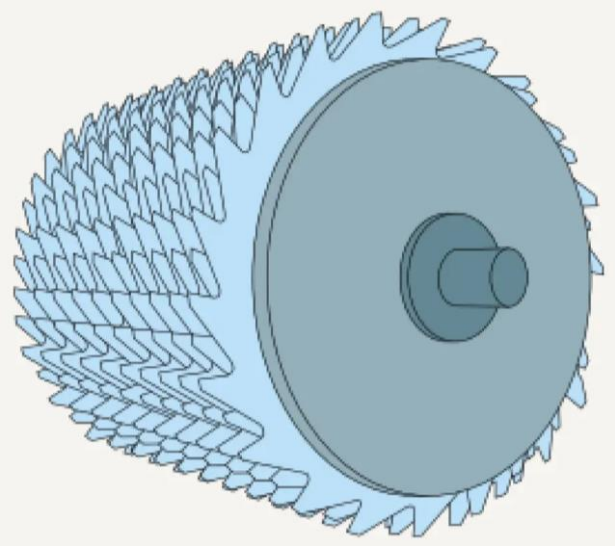
How blending is possible?

- Bale layout

Opening of tufts: different principles

Teasing out by Tooth disc

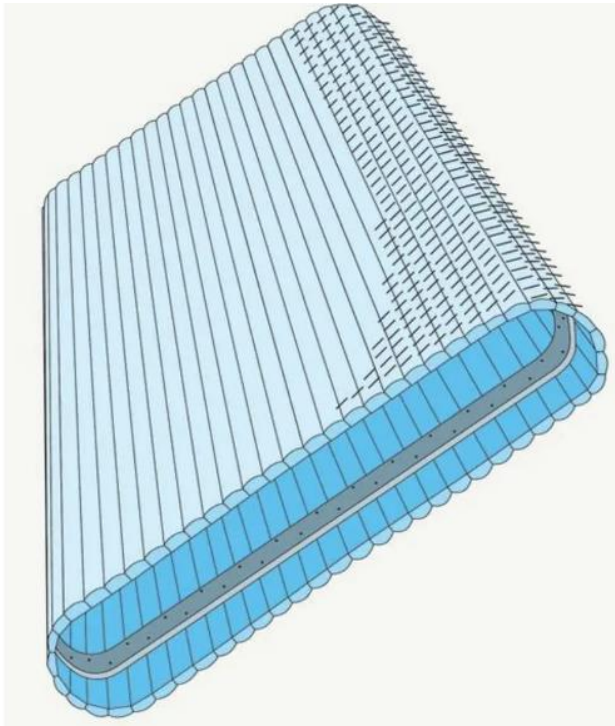
- ✓ **Tooth discs have triangular plucking elements**
- ✓ **The discs are secured to a shaft**
- ✓ **Asymmetrically formed**
- ✓ **Operate only in one direction**
- ✓ **If the disc needs to operate in both direction ?**

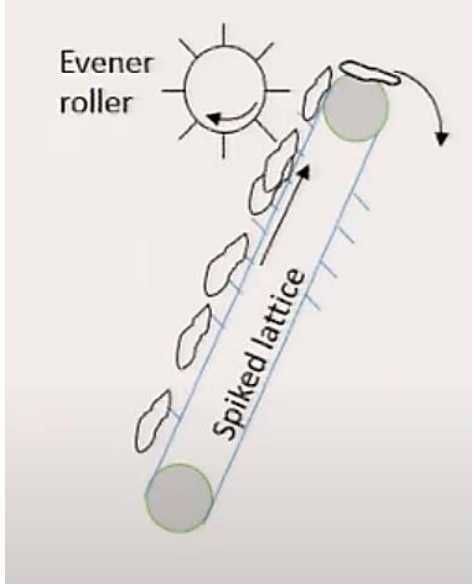


Opening of tufts: different principles

Tearing

- ✓ Tufts are acted by oppositely moving spikes and torn apart into pieces
- ✓ Thorough mixing How?
- ✓ Formation of neps
- ✓ The intensity of opening action depends on
  - Distance between the spiked devices
  - Speed relationships
  - Total working surface
  - No. of points



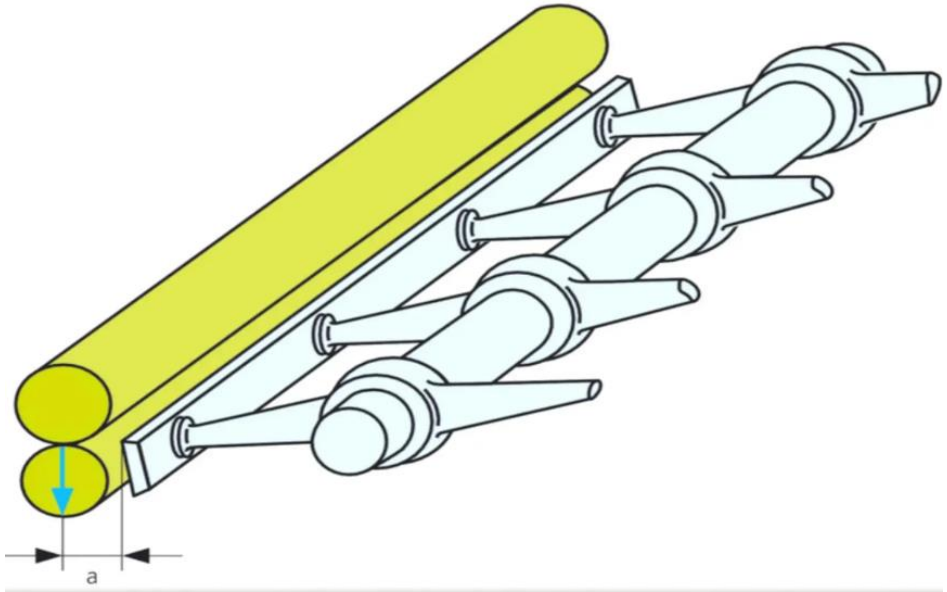


Mild action

Opening of tufts: different principles

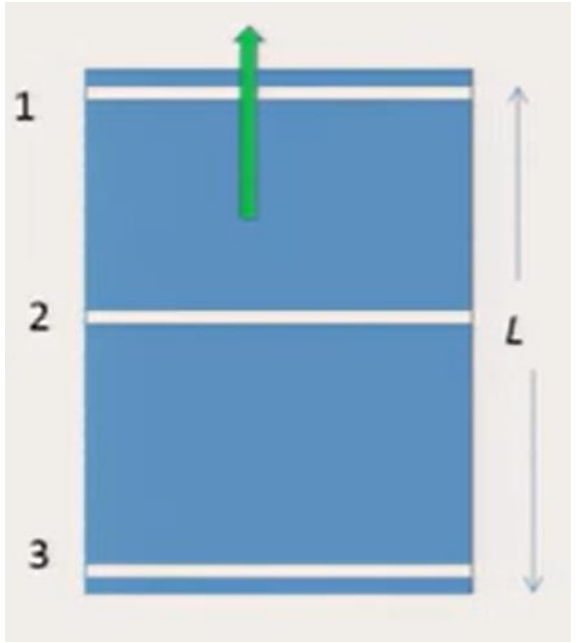
Impact by Bladed Beaters

- ✓ **Consists of 2-3 beater bars**
- ✓ **In one rotation, the feed sheet receives 2-3 blows across the full width**



Opening and cleaning effect?

Low

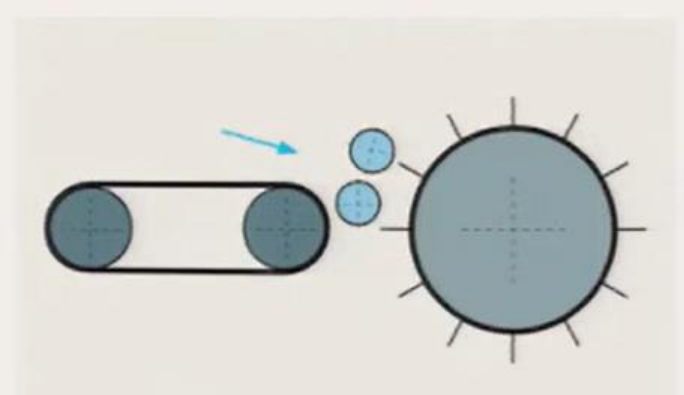


Feed length in one rotation

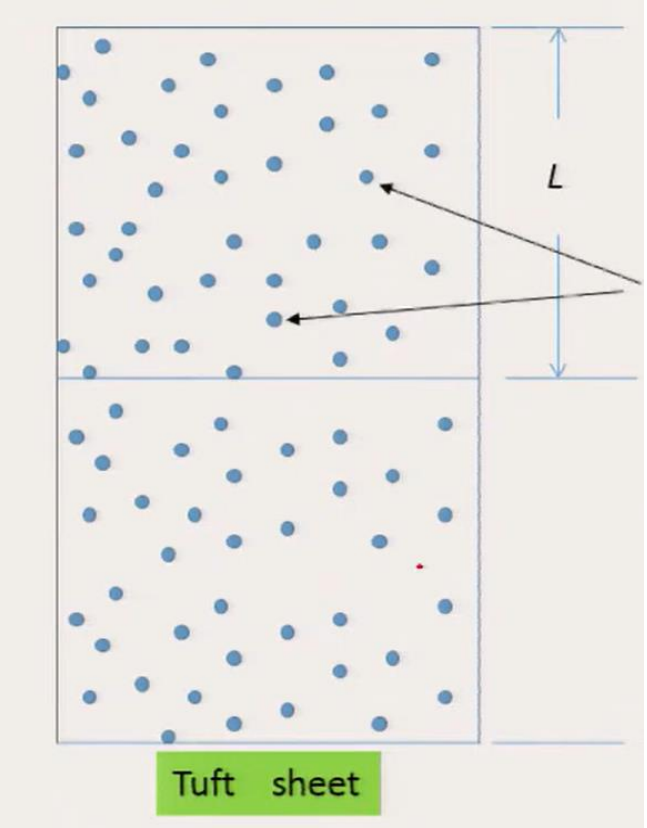
Beating lines on tuft sheet

Opening of tufts: different principles

Impact by Strikers



- ✓ Flat, oval or round bars are riveted or screwed to a cylinder
- ✓ Various spacing of the strikers elements may be used. Why?
- ✓ Speed: 600 – 1000 rpm



Striking points

Opening intensity depends on

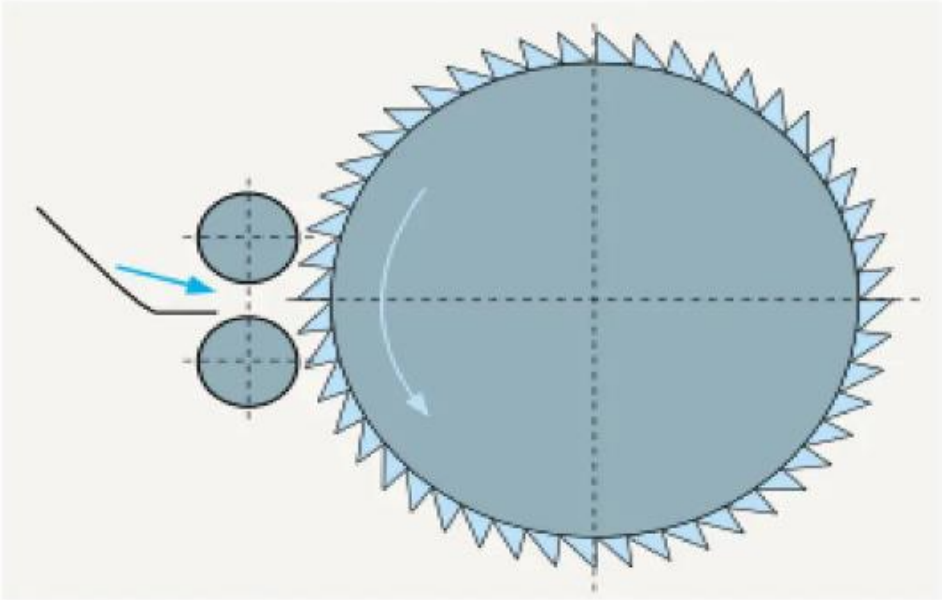
- ✓ Distance between feeding and opening elements
- ✓ Speed ratio
- ✓ Number of striking elements

Why are the striking elements staggered?

Opening of tufts: different principles

Teasing out by Saw teeth

- ✓ A cylinder surface filled with saw tooth
- ✓ Fine setting between the elements
- ✓ Suitable for smaller flocks
- ✓ Generate new surfaces
- ✓ Spacing between teeth : 6 - 8.5 mm
  Tooth height: 4.5 - 5.5 mm

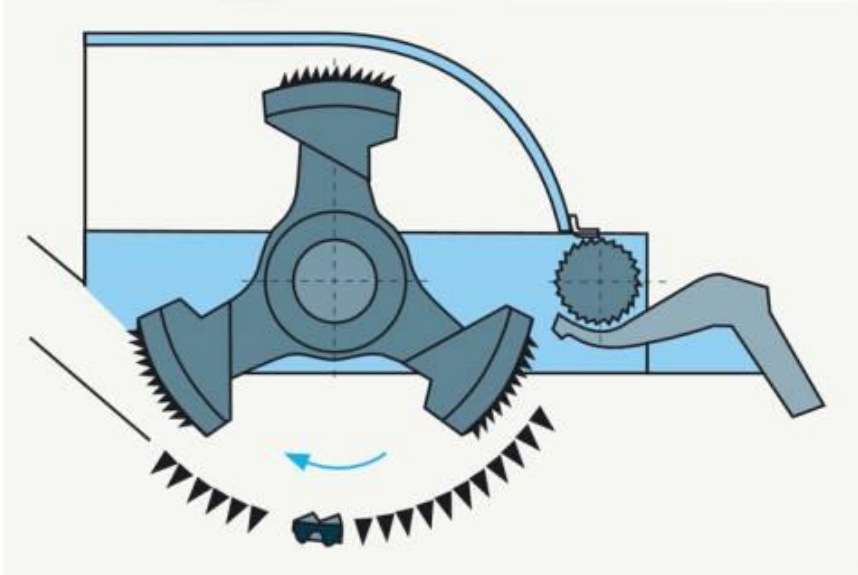


Suitable for finest opening and best cleaning.

Opening of tufts: different principles

Teasing out by Needles

- ✓ Pinned bars are secured to the cast iron arms
- ✓ The inclined pins penetrate and combs through the fibres
- ✓ Generates new tuft surface and liberates trash particles
- ✓ Operates at 800-900 rpm



Kirschner Beater

Cleaning efficiency is very high

Opening Intensity

✓ Fibre Mass/Striker

$$\text{Intensity of opening } (I) = \frac{P \times 10^6}{60 \times n_b \times N}$$

P = production rate (Kg/h), n_b = beater speed (rpm), N= number of strikers

✓ Blows/Kg

$$N_k = \frac{Blows\ per\ hour}{Production\ per\ hour\ (Kg)} = \frac{1}{P}(60 \times n_b \times N)$$

✓ Beats/inch

$$\text{Intensity} = \frac{Speed\ of\ beater \times number\ of\ blades\ on\ beater}{Delivery\ of\ feed\ roller}$$

$$= \frac{Speed\ of\ beater \times number\ of\ blades\ on\ beater}{Circumference\ of\ feed\ roller \times speed\ of\ feed\ roller}$$

Typical beats per inch: 30-50

Cleaning Principle

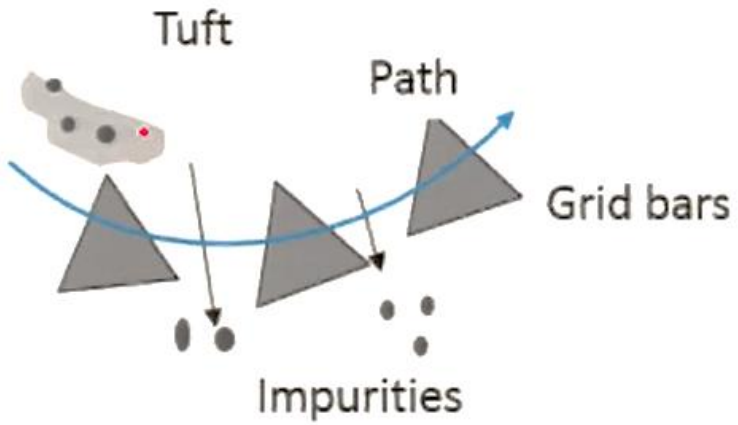
Trash Liberation

Trash Separation

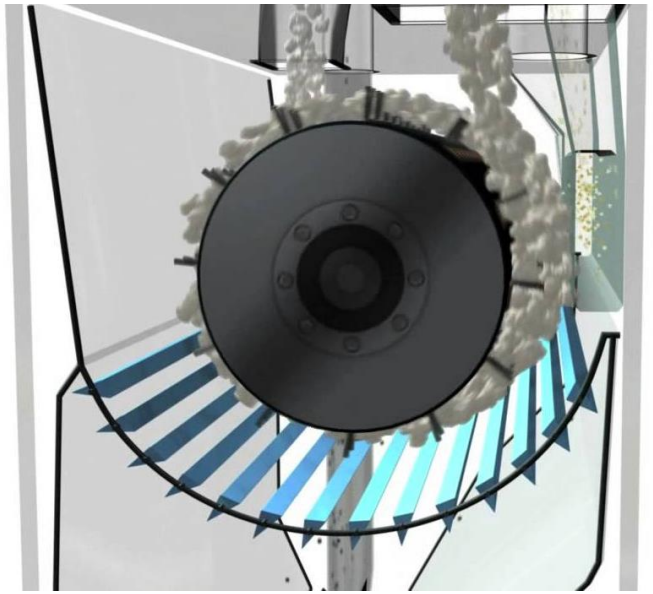
Mechanism of Trash Liberation

- ✓ Loss of kinetic energy (scrubbing)
- ✓ Impulse (Beating)
- ✓ Centrifugal force
- ✓ Pneumatic force

Loss of kinetic energy (scrubbing)



- ✓ **Fibre tufts are guided over stationary grid bars**
- ✓ **The kinetic energy of trash particles after impact becomes almost zero and liberated from fibre tufts**

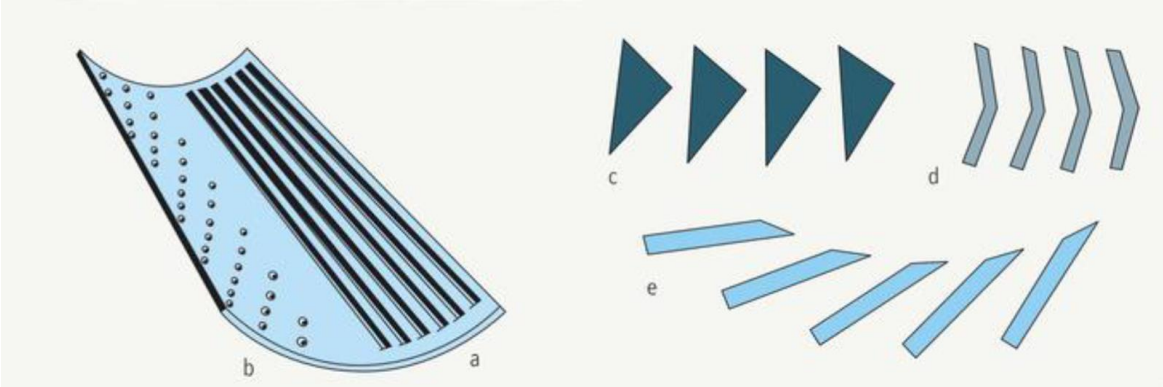


What is separation mechanism?

The liberated particles fall down due to gravity and separated

Mechanism of Trash Liberation

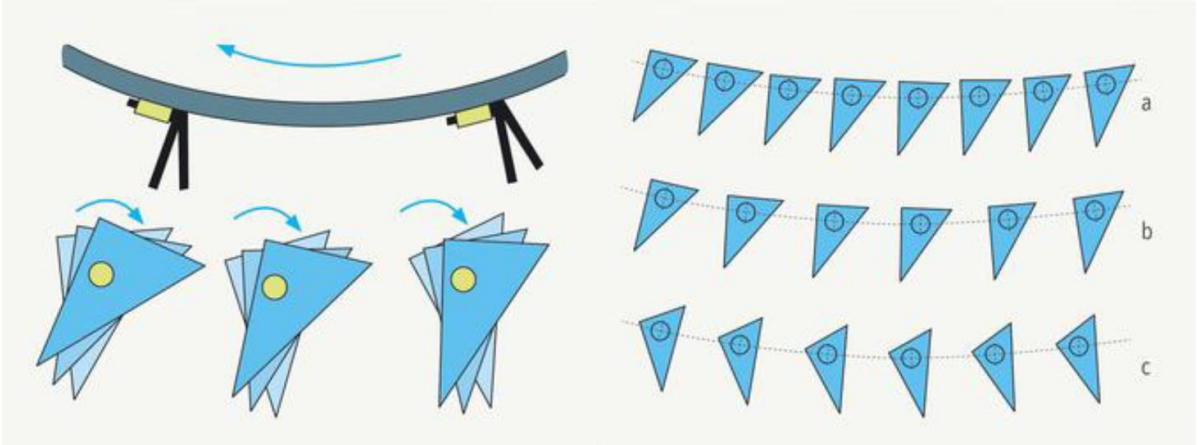
Grid Bars



Cleaning action depends on:

- ✓ Distance of grid bars from beater
- ✓ Gaps between the bars
- ✓ Setting angle related to the beater

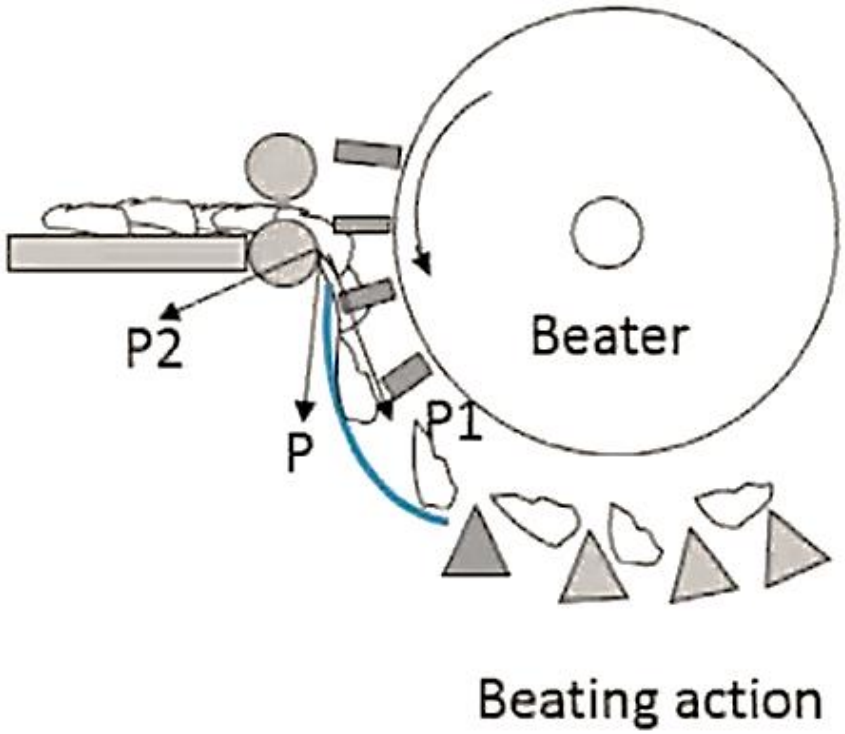
- ✓ **Slotted sheets (a):** Poor cleaning
- ✓ **Perforated sheets (b):** Poor cleaning
- ✓ **Triangular section bars (c): Mostly used**
- ✓ **Angle bars (d):** Moderate cleaning
- ✓ **Blades (e):** Strong and effective



Mechanism of Trash Liberation

Impulse (Beating)

- **Flocks are fed by feed rollers and are subjected to strong blows by the blades of a beater.**
- **Velocity of tufts changes instantly (in microseconds)**



Beating action

Impulse: change in momentum

$$= m(v_i - vf)$$

m is the mass of tuft, v_i is the initial velocity, v_f is the initial velocity, i.e., feed roller surface speed, final velocity (surface speed of bater at the top of strikers)

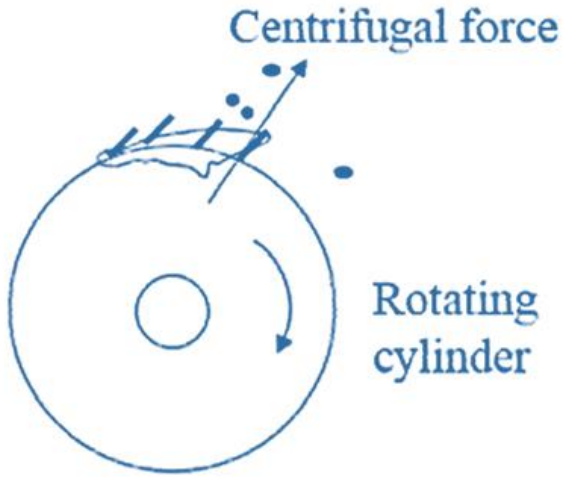
How the trash will be separated?

Mechanism of Trash Liberation

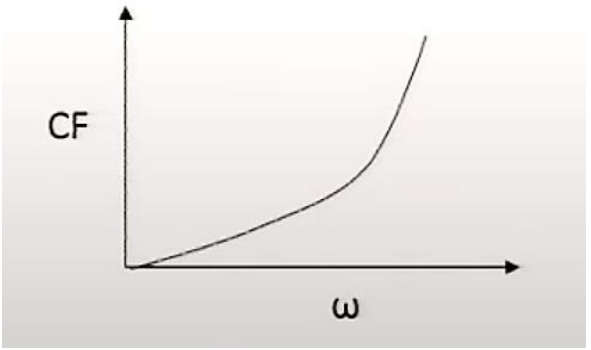
Centrifugal force

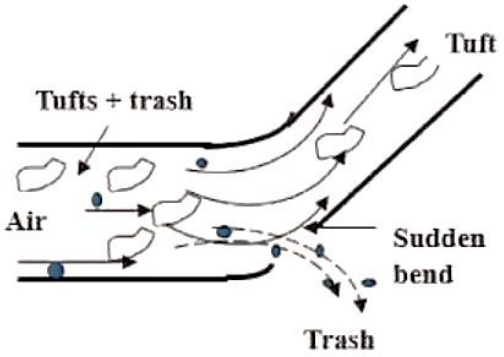
- ✓ **Trash particles resting on the saw tooth, strikers or blades are subjected to a high centrifugal force.**
- ✓ **Trash particles have low attachment with the striking elements.**

$$CF = mr\omega^2$$



What is the trash separating mechanism?

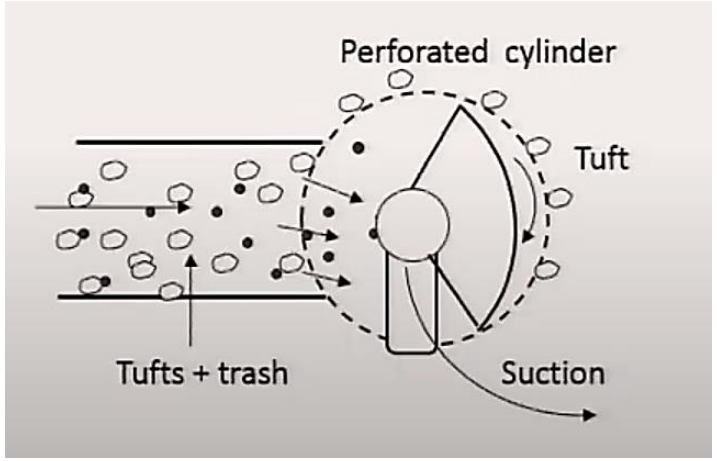




Mechanism of Trash Separation

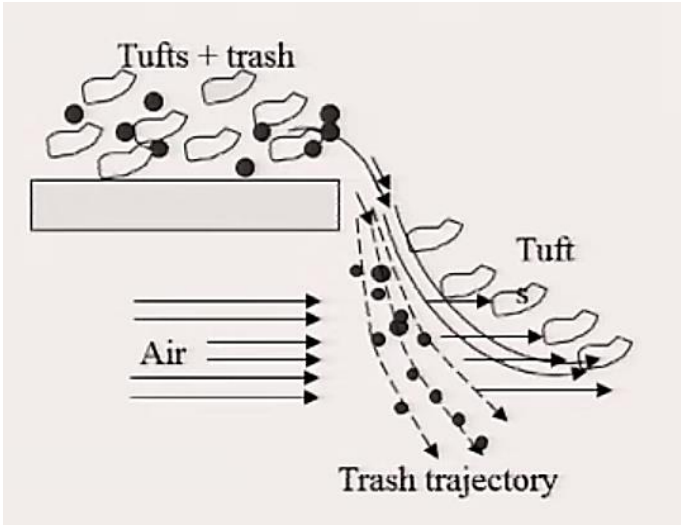
Pneumatic force

- ✓ **Trash with liberated trash particles are directed towards a moving perforated screen.**
- ✓ **Trash particles are sucked through the perforations**



Separation by buoyancy difference

- ✓ **Mixture of tufts and trash particles are directed downwards**
- ✓ **A stream of air flow cross the path horizontally.**



Dust and Metal Removal

Dust Removal

Difficulties:

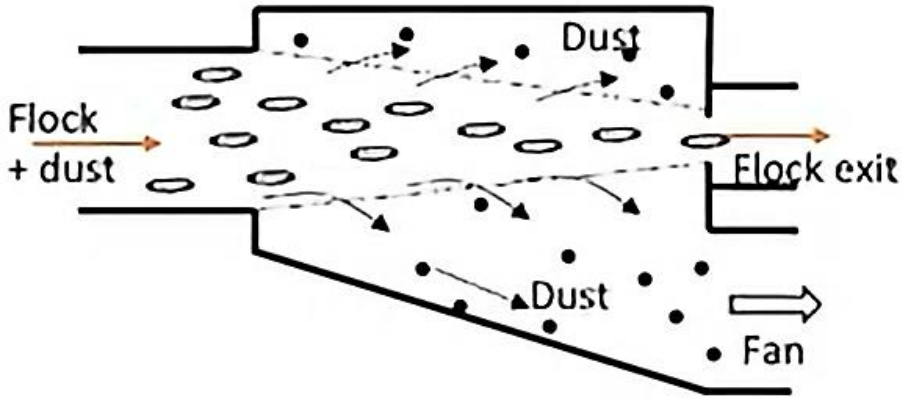
- ✓ Dust is lighter than fibres
- ✓ Strong adherence with fibres

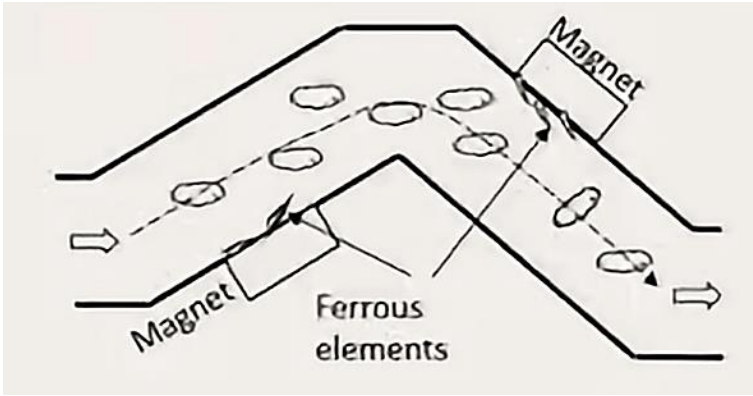
Liberation mechanism:

- ➢ High metal to fibre friction
- ➢ Fibre to fibre friction

Separation Mechanism:

- ✓ Through suction



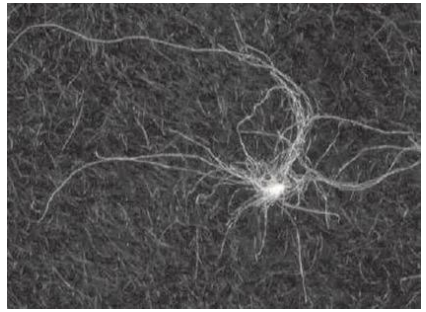


Metal Extractor

Cleaning Efficiency

$$\text{Cleaning efficiency (CE \%)} = \frac{\textit{Trash in feed}\ (\%) - \textit{trash in delivery}\ (\%)}{\textit{Trash in feed}\ (\%)} \times 100$$

- The CE % of individual cleaner varies according to their type and position
- The beater or cleaner in the beginning of the blowroom line shows
  - higher cleaning efficiency
- More cleaning means more waste and loss of good fibres (lint)
- Lint in the waste should be in the range of 20-30%.
- After opening and cleaning nep level in blowroom increases significantly
  - due to blunt opening elements and grid bars
  - due to repeated action of beaters or strikers



Opening and Cleaning Principle

What we have learnt so far……

Importance of Yarn manufacturing in India

- India is the world's second largest cotton producing country
- India has the world's second largest spinning capacity after China
- Ample opportunities in Technical Textiles (NTTM), entrepreneurship, machine manufacturing, etc.

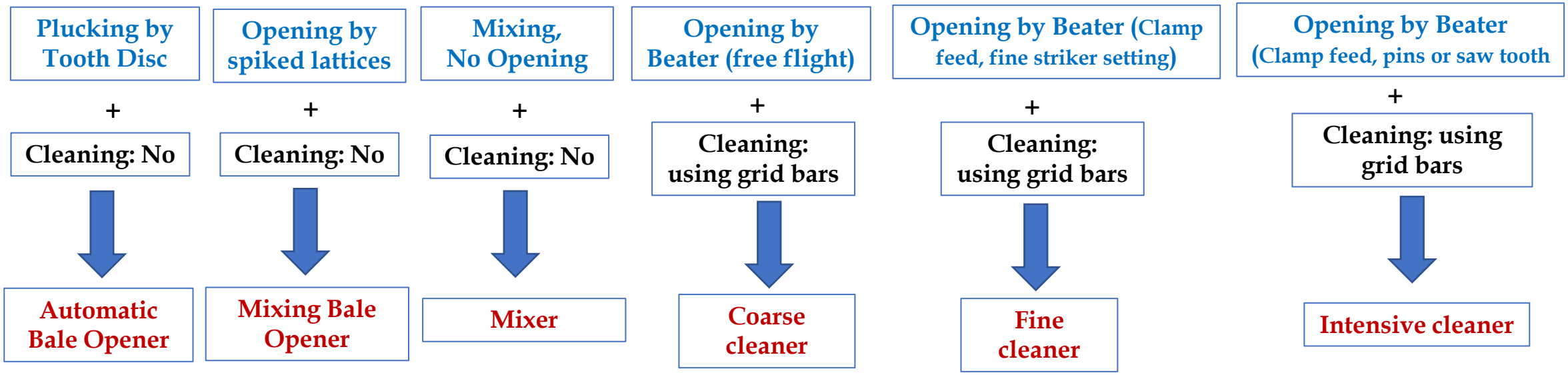
Different Steps in Yarn Manufacturing

Objectives and Principles of Opening and Cleaning

- What is opening?
- Why and how opening is done?
- Why and how cleaning is done?
- Why does a blowroom line need a specific opener and cleaner at a specific place?
- How opening and cleaning intensity are measured?
- What are the parameters which affect opening and cleaning intensity?

New Opening and Cleaning Principles……

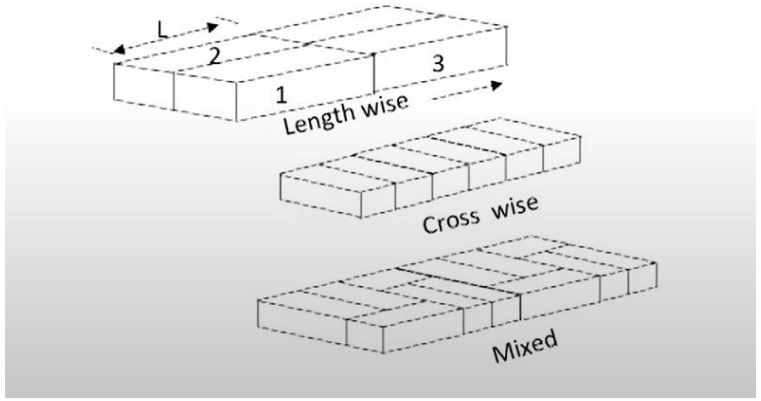
Blowroom Machines

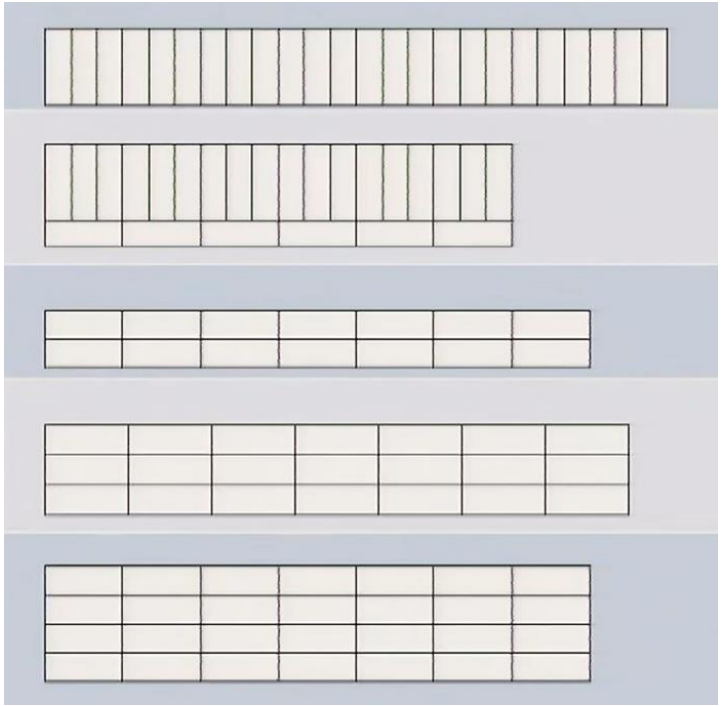


Blowroom Machines

Blowroom Machines

Automatic Bale Opener: Unifloc (Rieter)



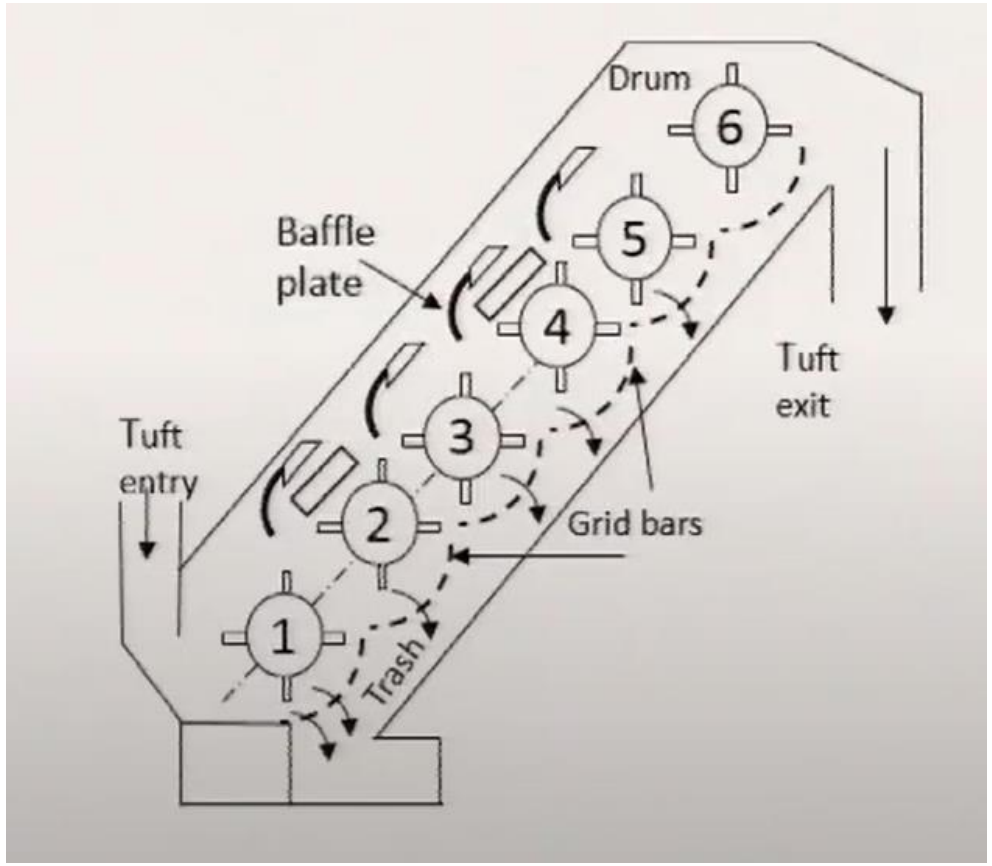


Bale lay down

- ✓ Rotating tooth discs pluck out fibre flocks (micro tufts)
- ✓ Bale height is automatically detected
- ✓ Depth of penetration: 2-4 mm
- ✓ Can turn by 180° to process bales on the other side
- ✓ Production: up to 2000 kg/hr

Blowroom Machines

Coarse Cleaner



Step Cleaner

- ✓ **Consists of series of drums with four rows of striking elements**
- ✓ **Grid bars cover 25% of individual drum chamber**
- ✓ **Inclination angle 45 to 60°**
- ✓ **Beater speed: 500 to 600 rpm**

Blowroom Machines

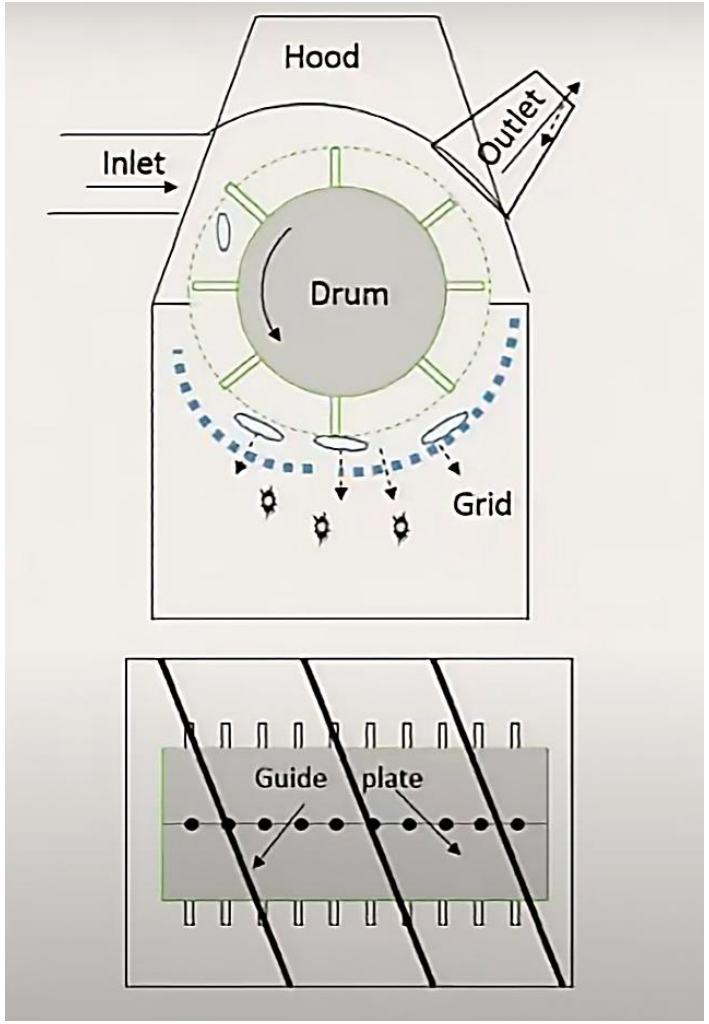
Coarse Cleaner

- ✓ The drum surface is covered with 6-8 rows of striking elements
- ✓ The fibre tufts enters at right angle to the beater axis and receives strikes
- ✓ The guide plates ensure than the fibre tufts follow a spiral path. Why?

RIETER

B 12 UNIclean

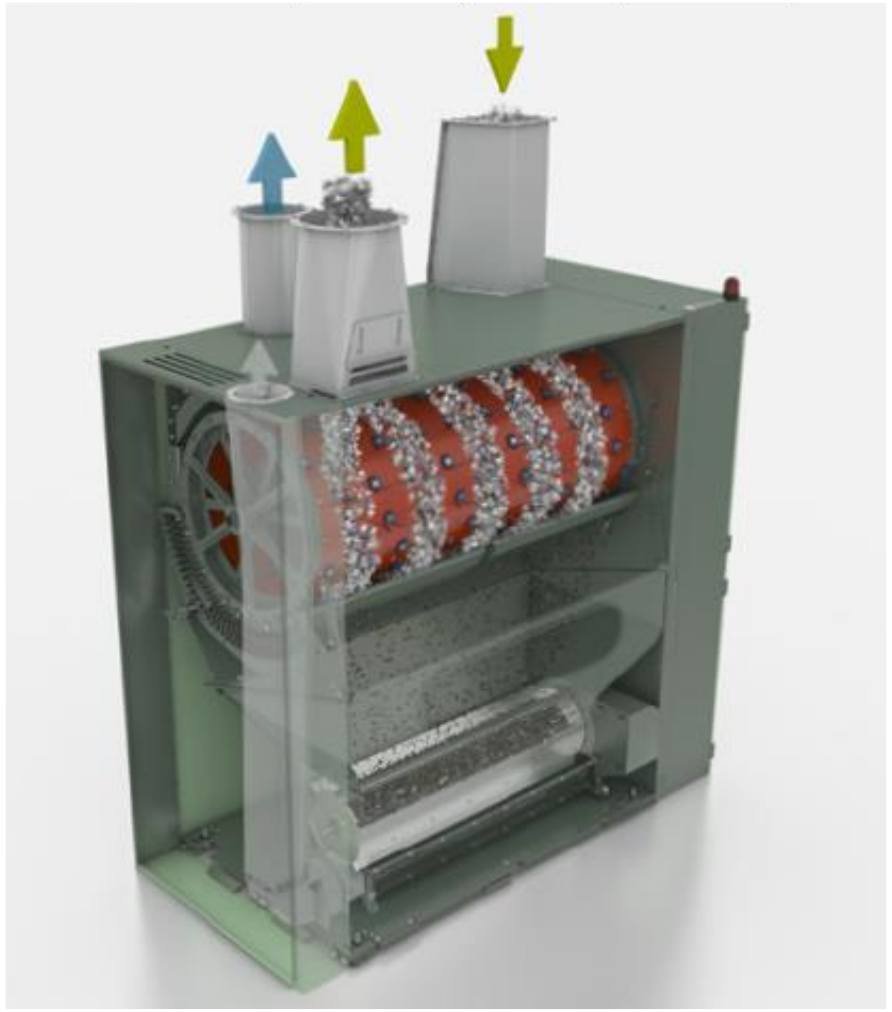
Efficient and reliable pre-cleaning



Monocylinder Cleaner

Blowroom Machines

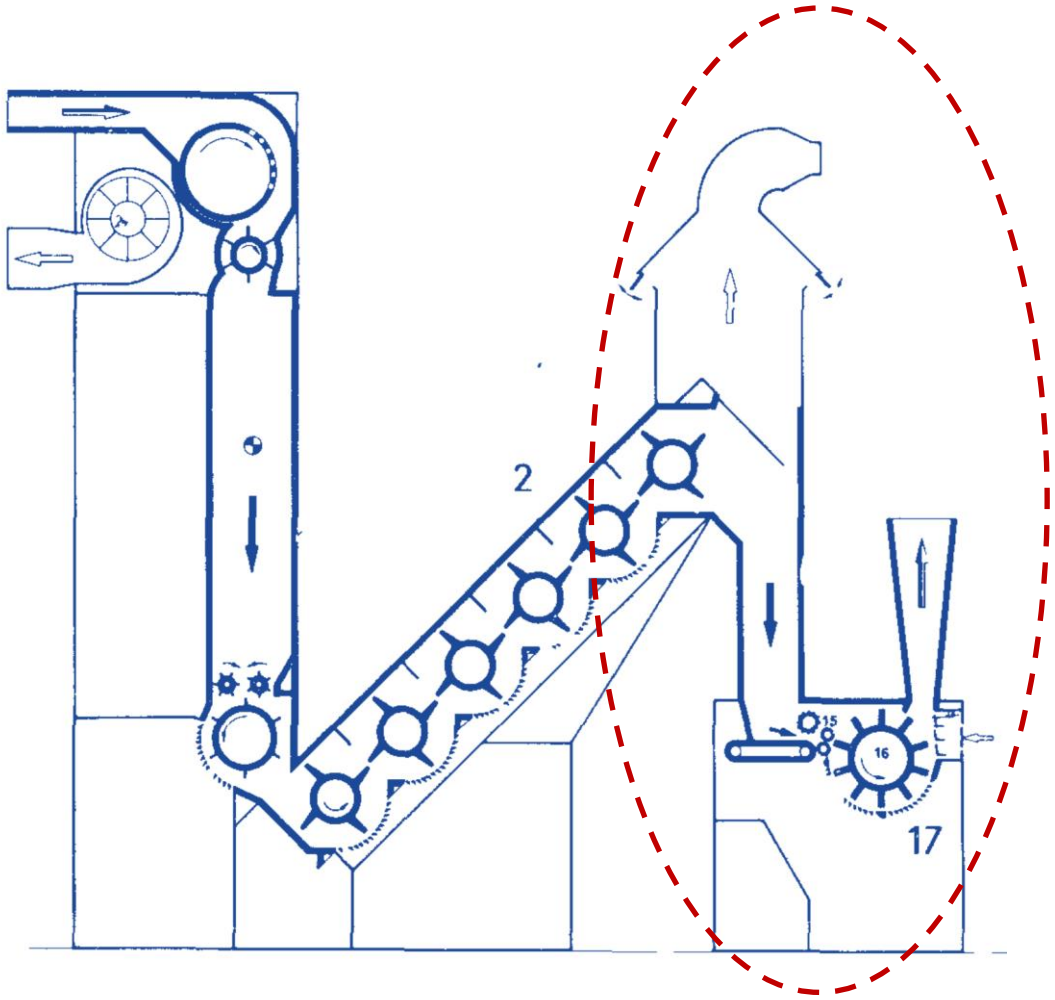
Coarse Cleaner



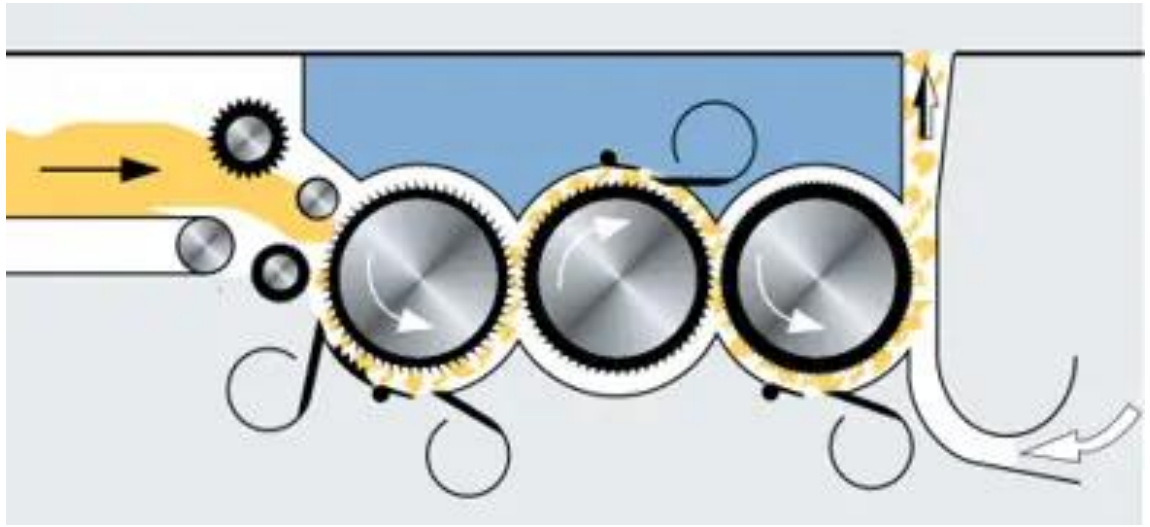
UNIclean B12

Blowroom Machines

Fine Cleaner



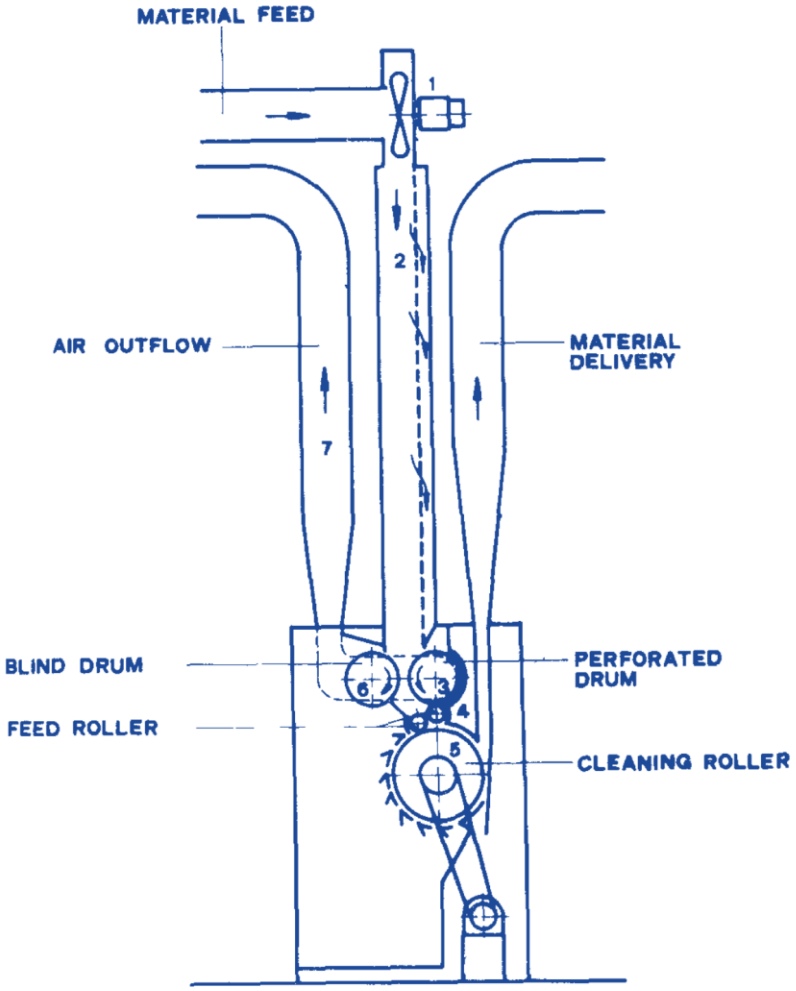
RN Cleaner (Trützschler)



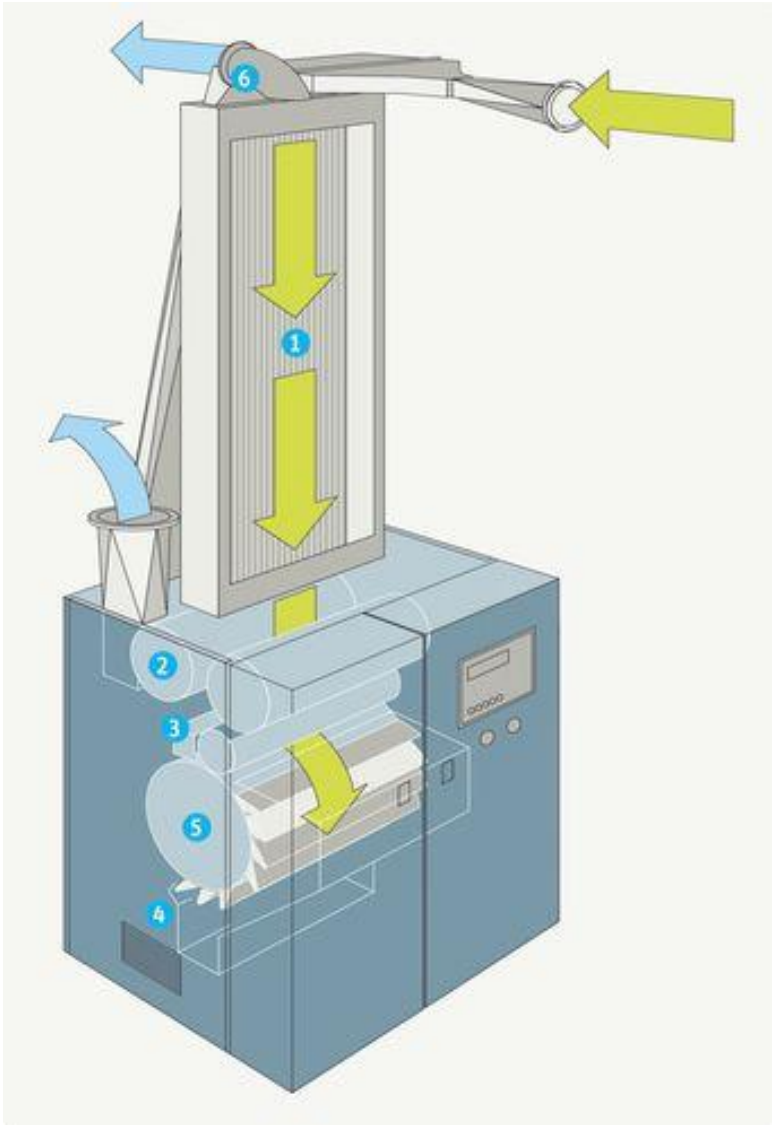
Cleaner CL-C3 **(Trützschler)**

Blowroom Machines

Intensive Cleaner



ERM Cleaner (Rieter)



Uniflex (Rieter)

Filing chute (1)

Perforated drum (2)

Feed roll (3)

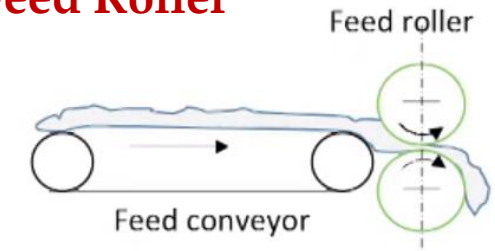
Grid bar (4)

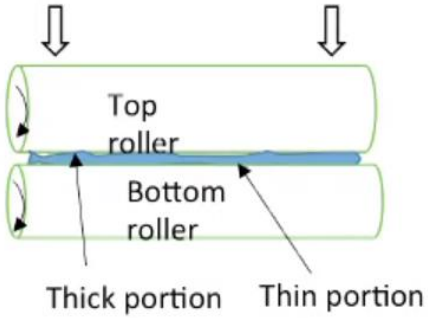
Opening cylinder (5)

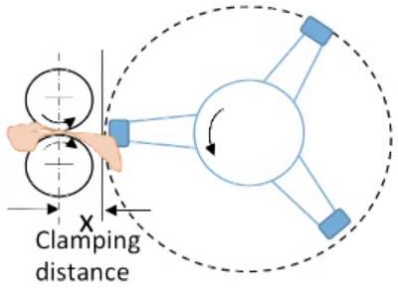
Blowroom Machines

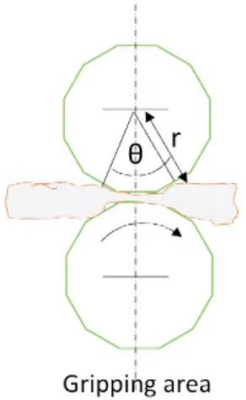
Different types of clamping device

Feed Roller





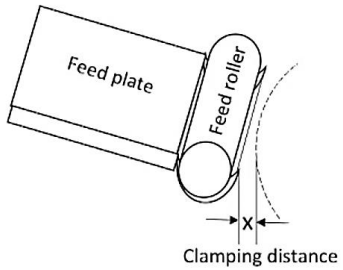


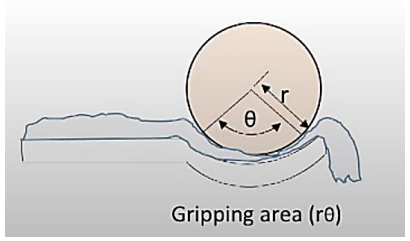


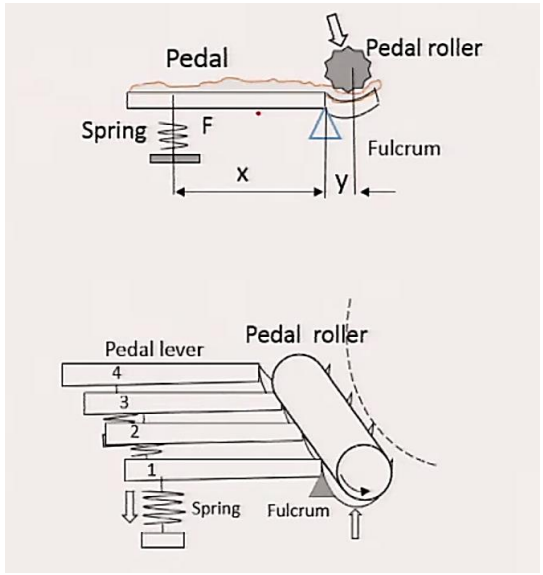
- ✓ Higher clamping distance
- ✓ Not powerful grip
- ✓ Uneven clamping

Feed Plate

- ✓ Small clamping distance
- ✓ More powerful grip
- ✓ Uneven clamping







Pedal rollers

- ✓ 16 pedal rollers
- ✓ Small clamping distance
- ✓ Even clamping

Piano Feed

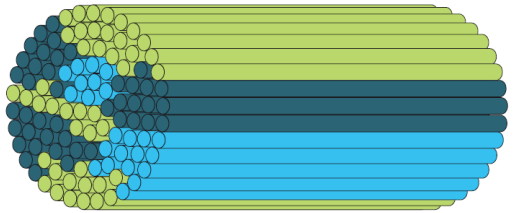
Blowroom Machines

Mixer/Blender

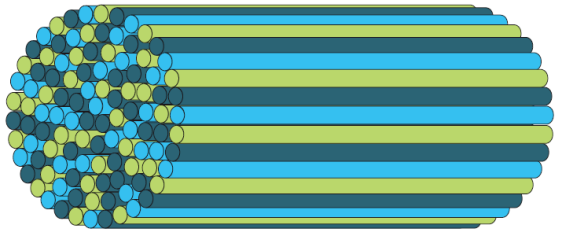
Purpose of blending/mixing

- ✓ To average out the variation in fibre characteristics
- ✓ To engineer a textile yarn with specific properties
- ✓ To produce a certain shade by mixing fibres of different colours
- ✓ To reduce the cost

Form	Stage	Machine
Bale	Blow room	Automatic bale opening machine
Flock/ tuft	Within blow room	1. Hand stack blending 2. Automatic blending equipment 3. Multi mixers
Lap	Within blow room	Scutcher
Sliver	Drawing , pre-combing stage, combing	Draw frame, sliver lap machine , comber draw box
Web	Pre combing stage, blending drawing	Ribbon lap machine , blending draw frame
Roving	Spinning	Ring spinning machine



Fibre blending using drawframe



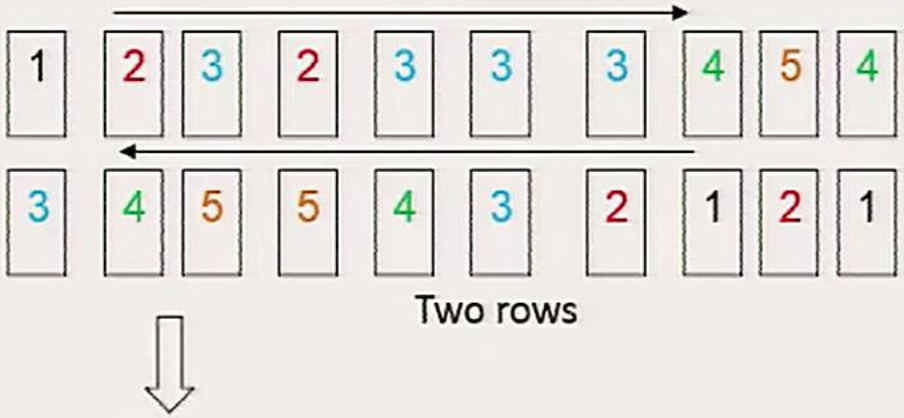
Fibre blending using blowroom

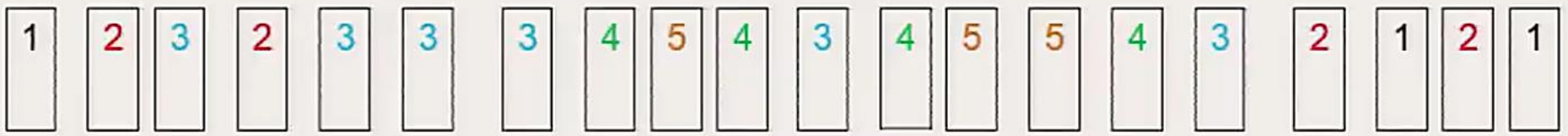
Blowroom Machines

Mixer

Mixing through bale lay down

Cate gory	Number	Odd/ even	U- side	L-side
1 (Shortest)	3	O	1	2
2	4	E	2	2
3	6	E	4	2
4	4	E	2	2
5 (Longest)	3	O	1	2
	20		10	10

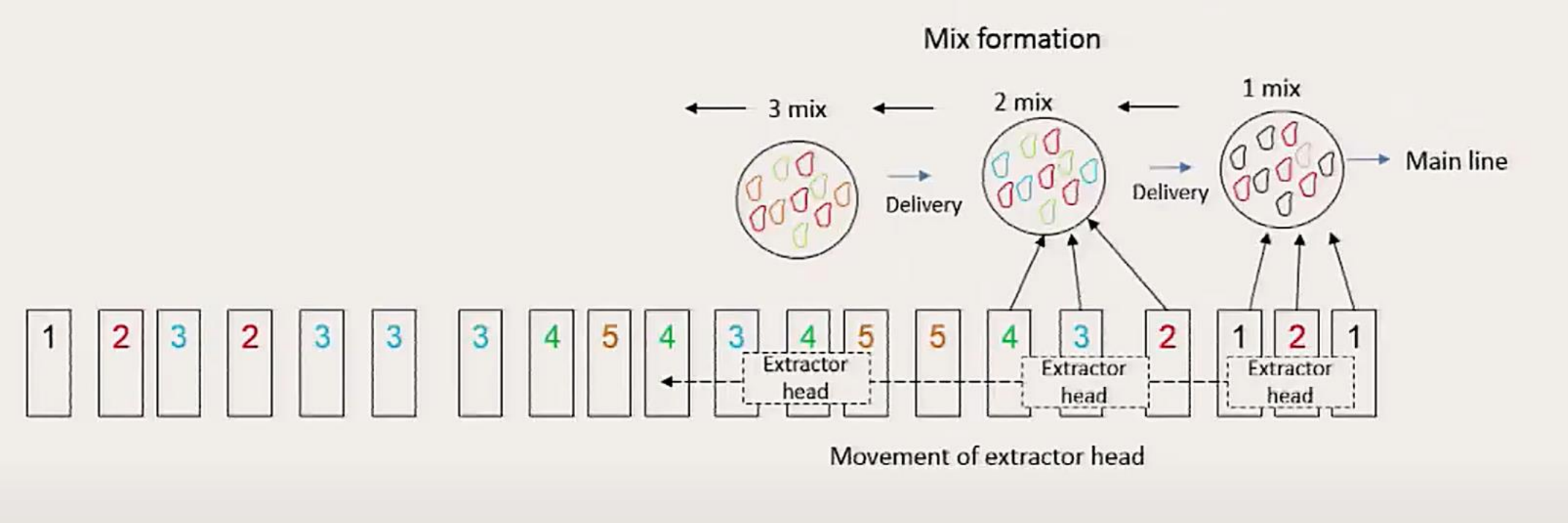




Blowroom Machines

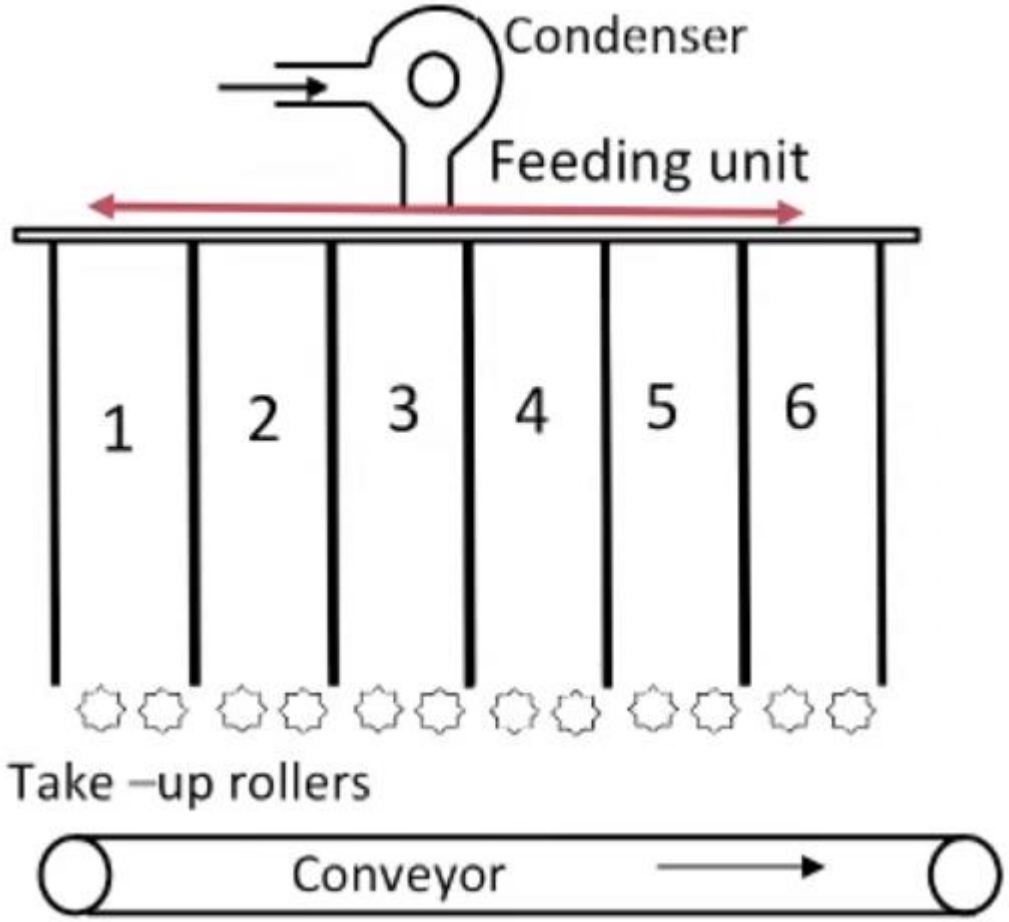
Mixer

Automatic bale opener does not give homogeneous mixing. Why?



Blowroom Machines

Multimixer

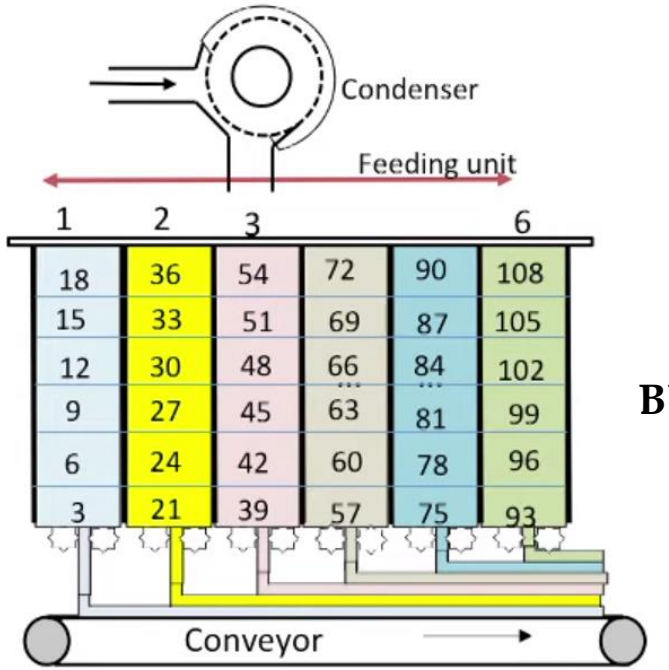


- ✓Consists of 6-10 vertical compartments
- ✓Cotton tufts are filled up to a certain filling height

Blowroom Machines

Multimixer

Discontinuous Operation

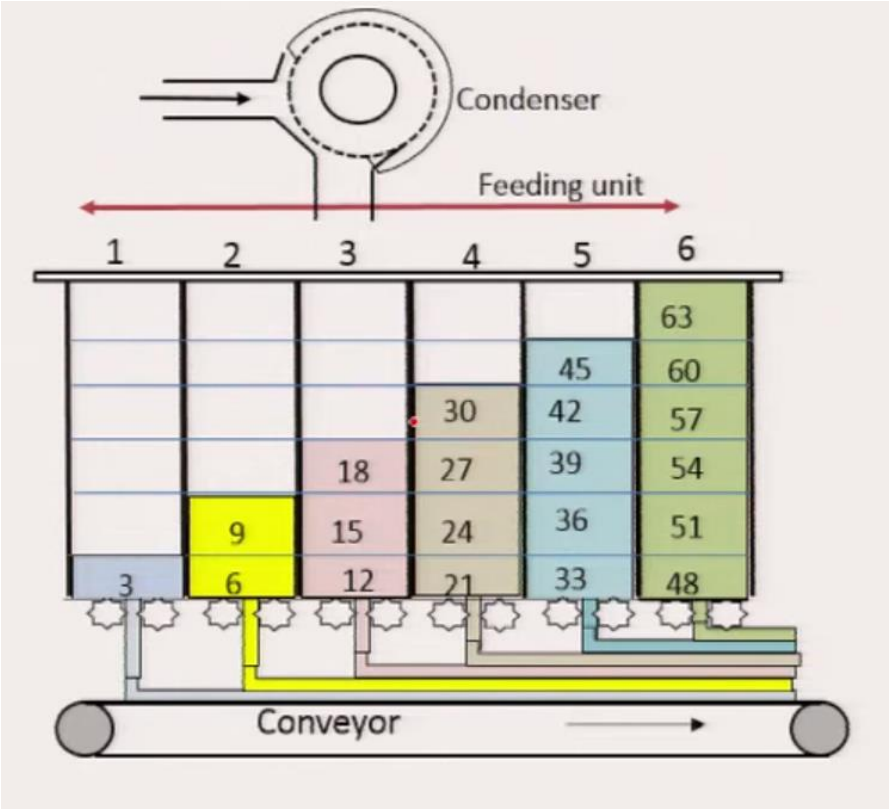


BDT = 93-3 = 90 min

The largest difference in the filling time of tufts in different boxes is known as Blending delay time (BDT)

BDT is constant in case of discontinuous operation

Continuous Operation

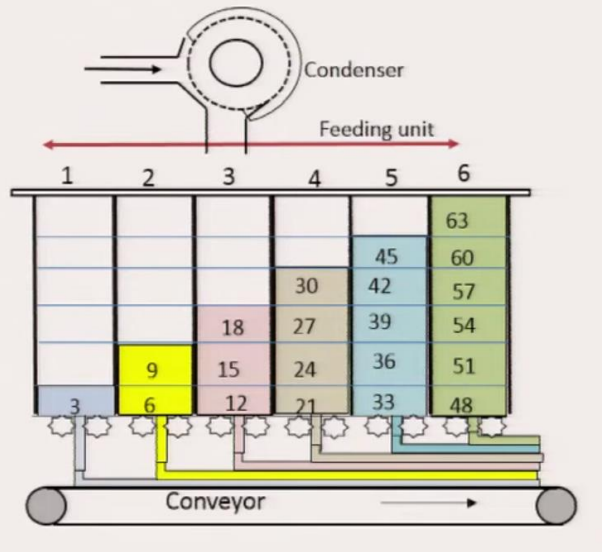


The compartments are filled up in a staggered configuration from 1st to last compartment

Blowroom Machines

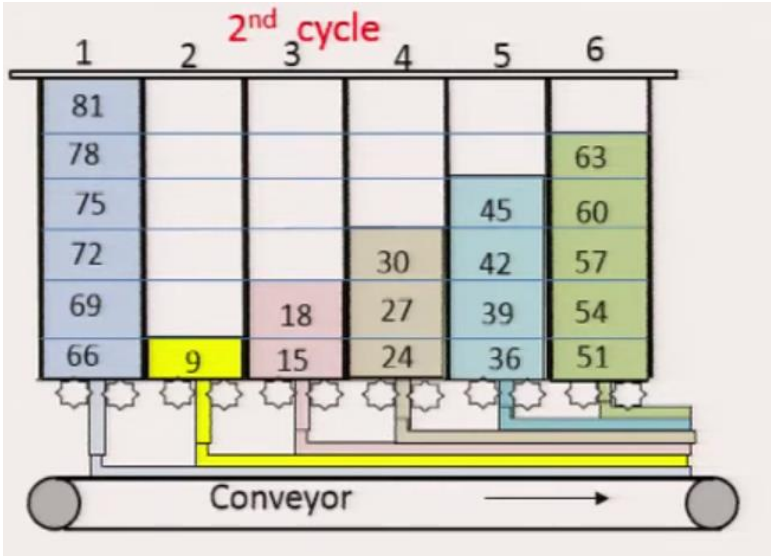
Multimixer

1st cycle



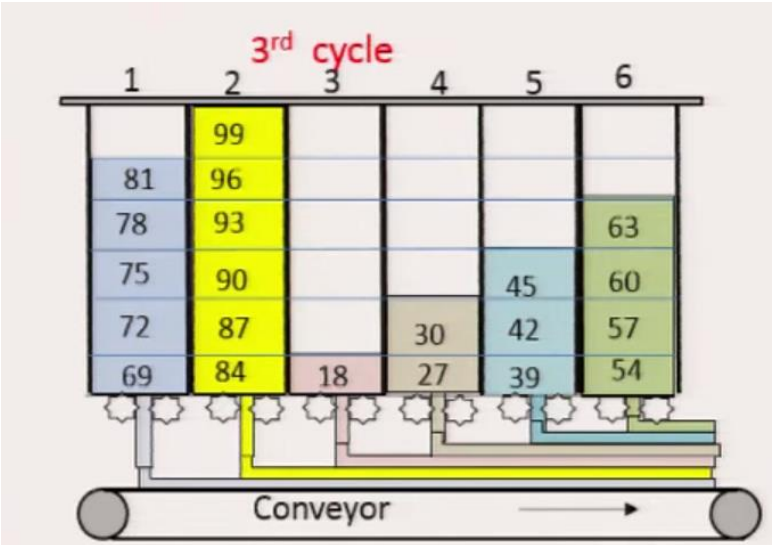
Blending delay time (BDT): 45 min

4th cycle:
Blending delay time (BDT): 72 min



Blending delay time (BDT): 57 min

5th Cycle:
Blending delay time (BDT): 75 min



Blending delay time (BDT): 66 min

6th cycle:
Blending delay time (BDT): 75 min

How BDT changes with feed cycle and number of compartments?

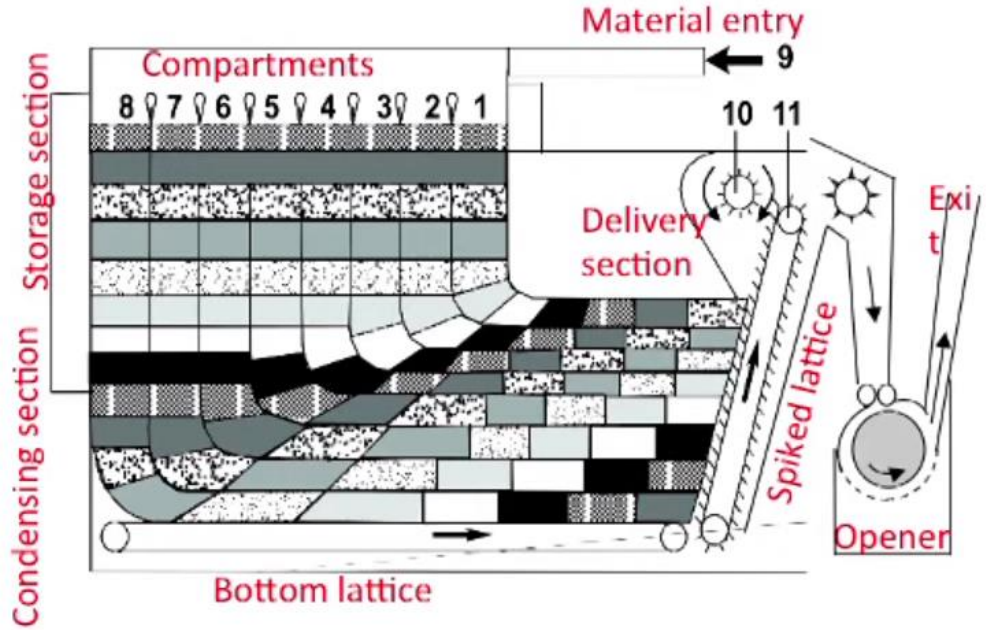
Blowroom Machines

Unimix (Rieter)

RIETER

B 76 UNImix

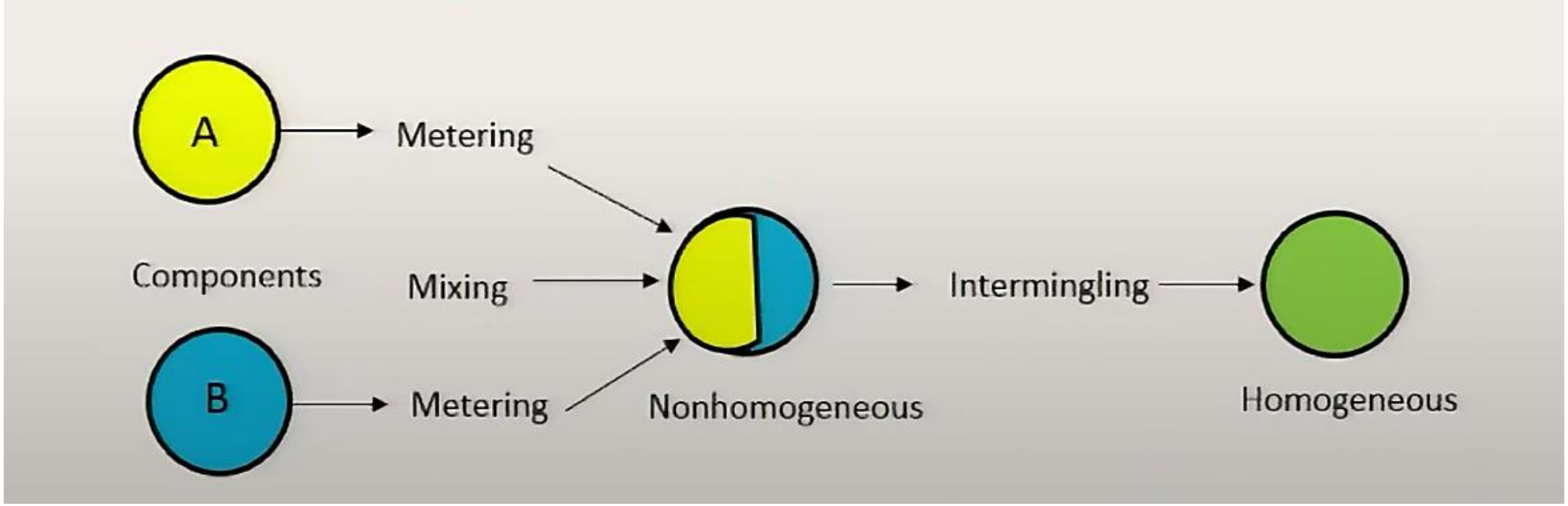
3-point mixing principle



90° bend in the material flow produces a shift in the timing resulting in long term blending

Blowroom Machines

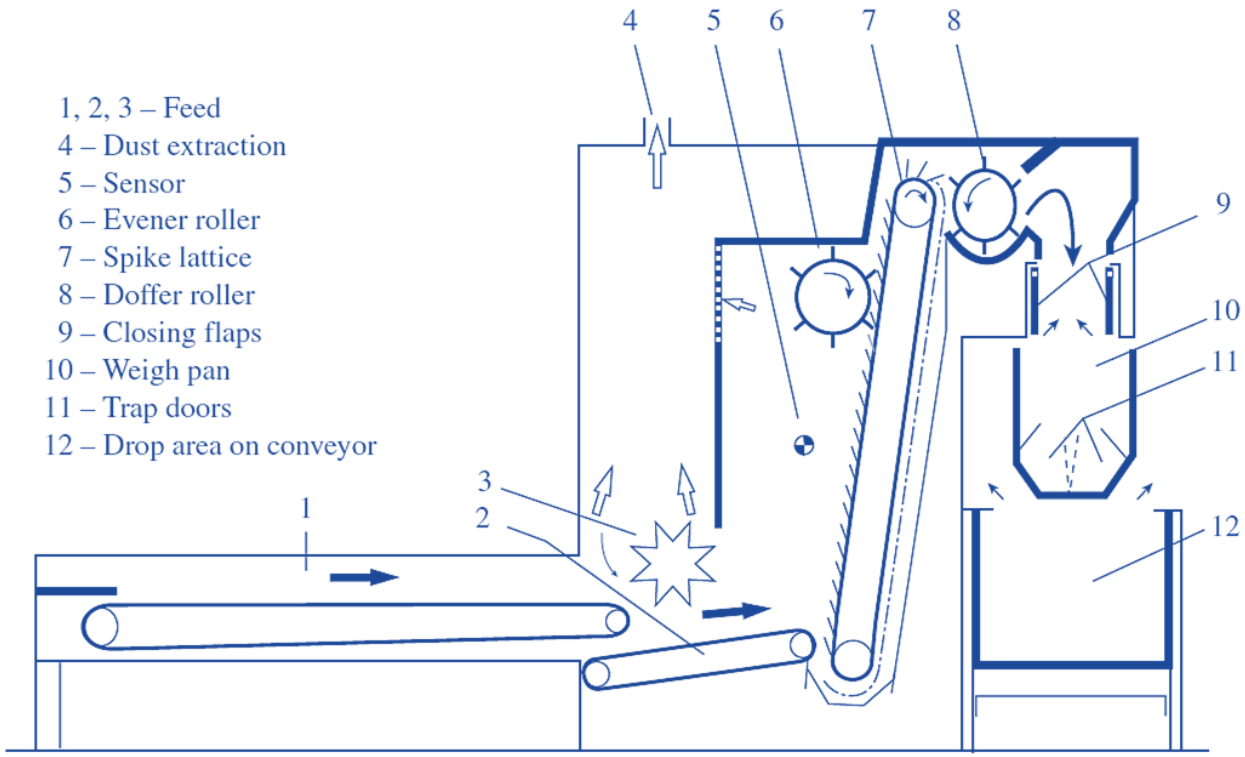
Blender

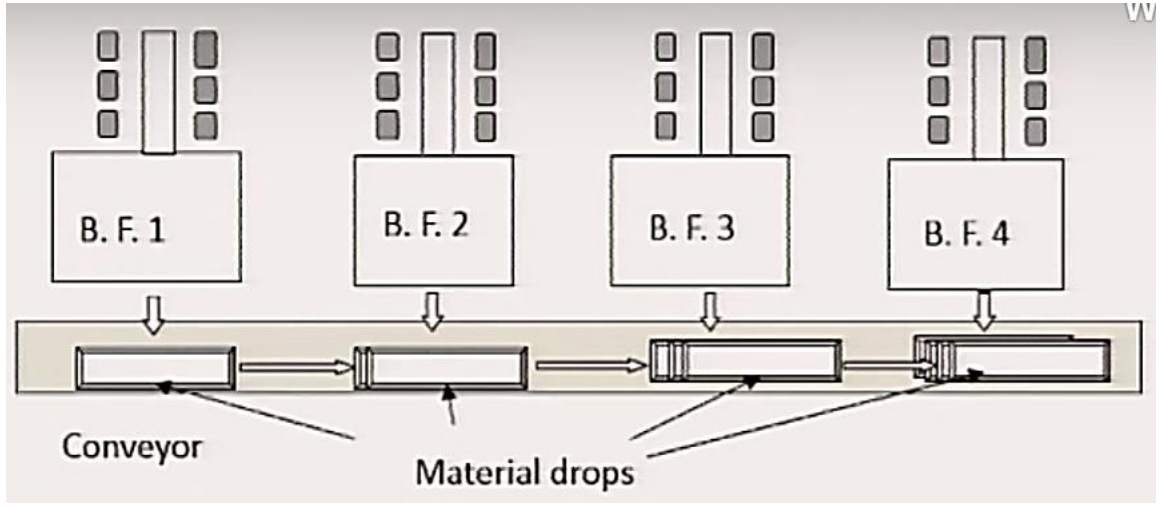


Metered amount of tufts are mixed together to maintain the blend ratio

Blowroom Machines

Blender

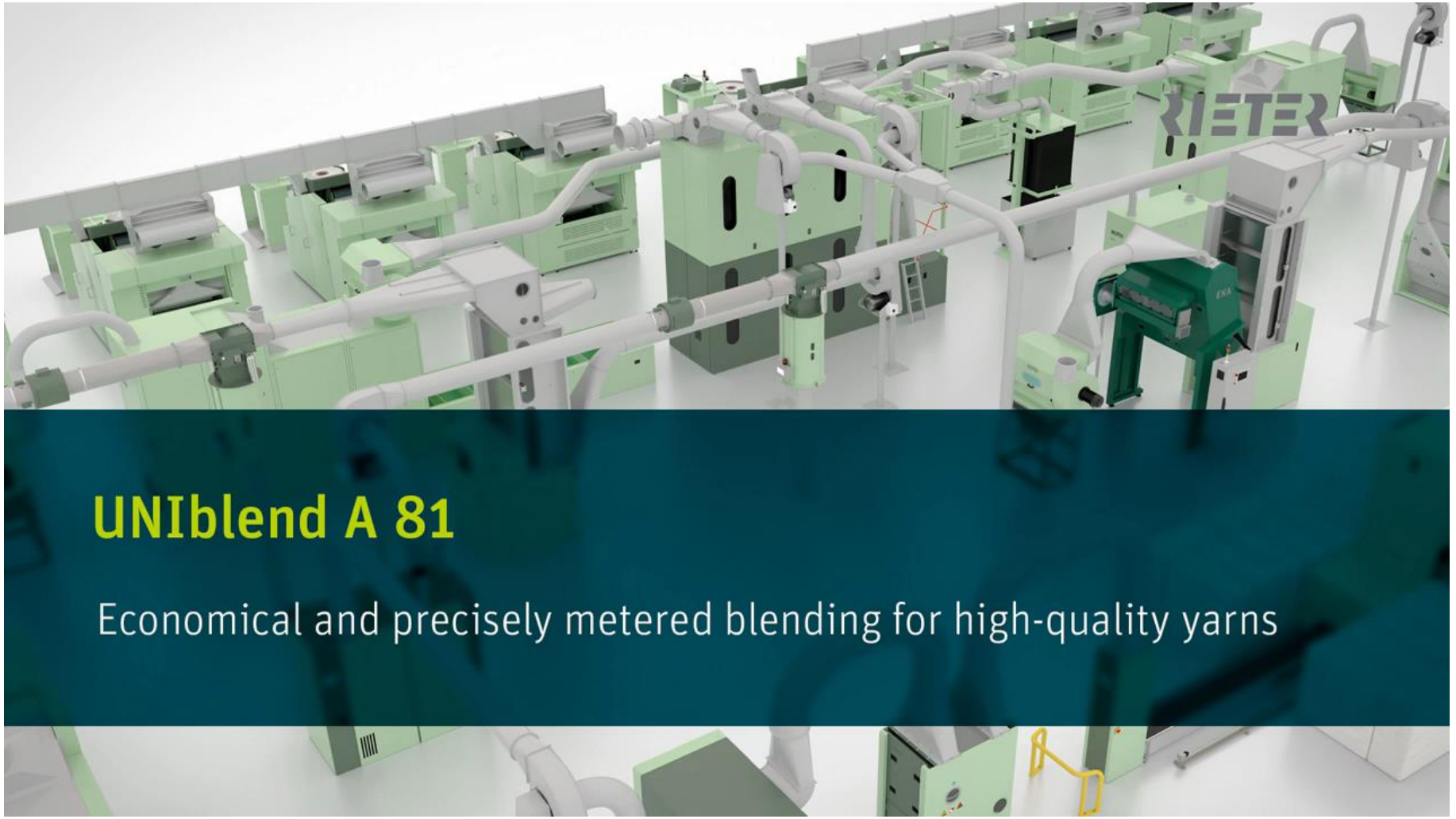




- ✓ **A metering system is used to drop a measured quantity of material to the conveyor belt**
- ✓ **Materials from 3-4 blenders are dumped together in sandwich form to form the blend**

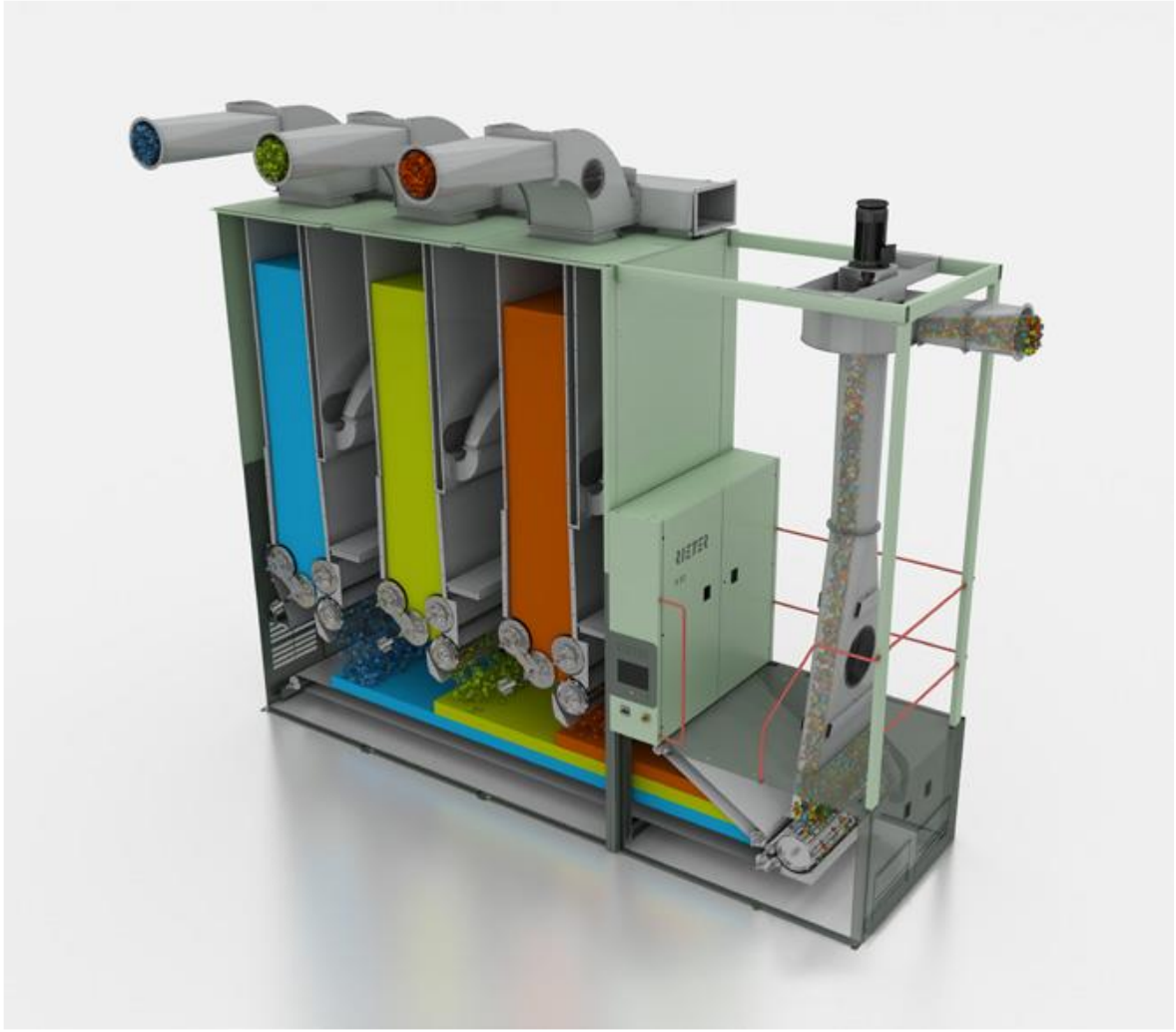
Blowroom Machines

Blender



Blowroom Machines

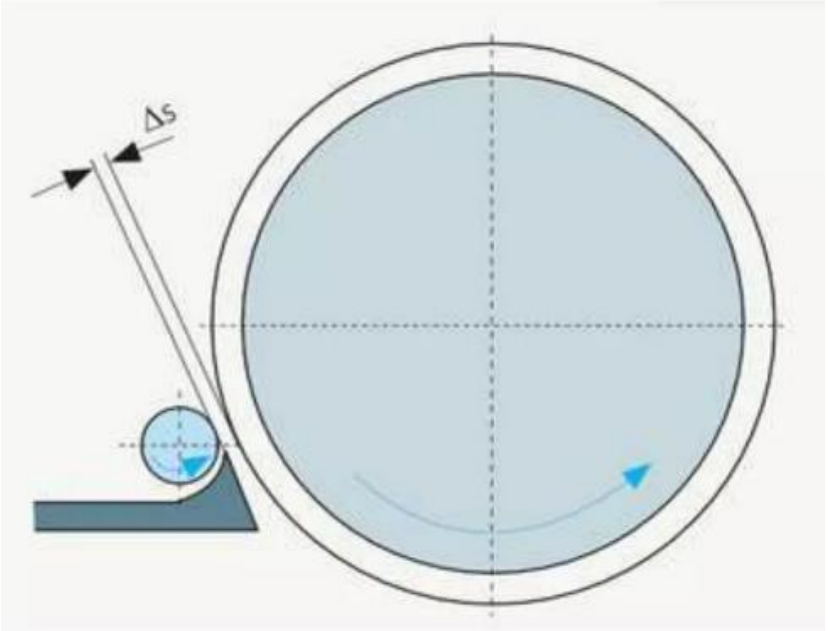
Blender



UNIblend A 81

Parameters influencing waste level

- ✓ The amount of trash (%) in feed
- ✓ Speed of the opening device
- ✓ Setting between feed roller and line of action of beater
- ✓ Grid bar inclination and opening

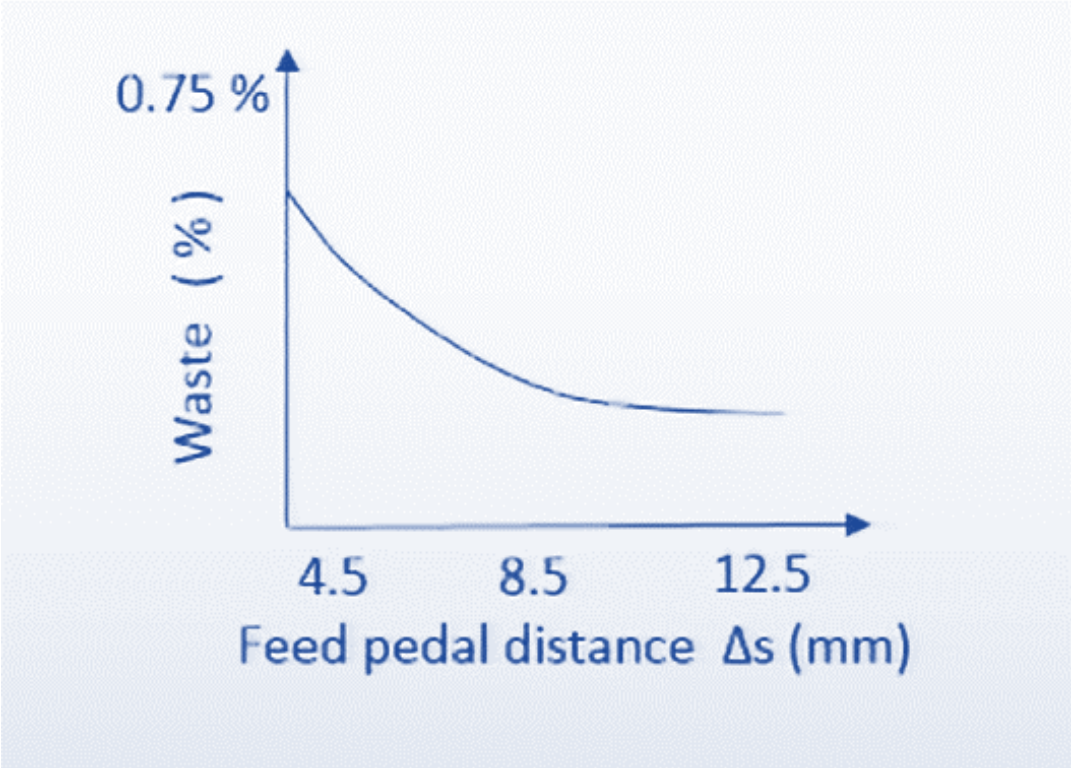


Parameters influencing waste level

Effect of trash%

Waste % increases linearly with the trash%

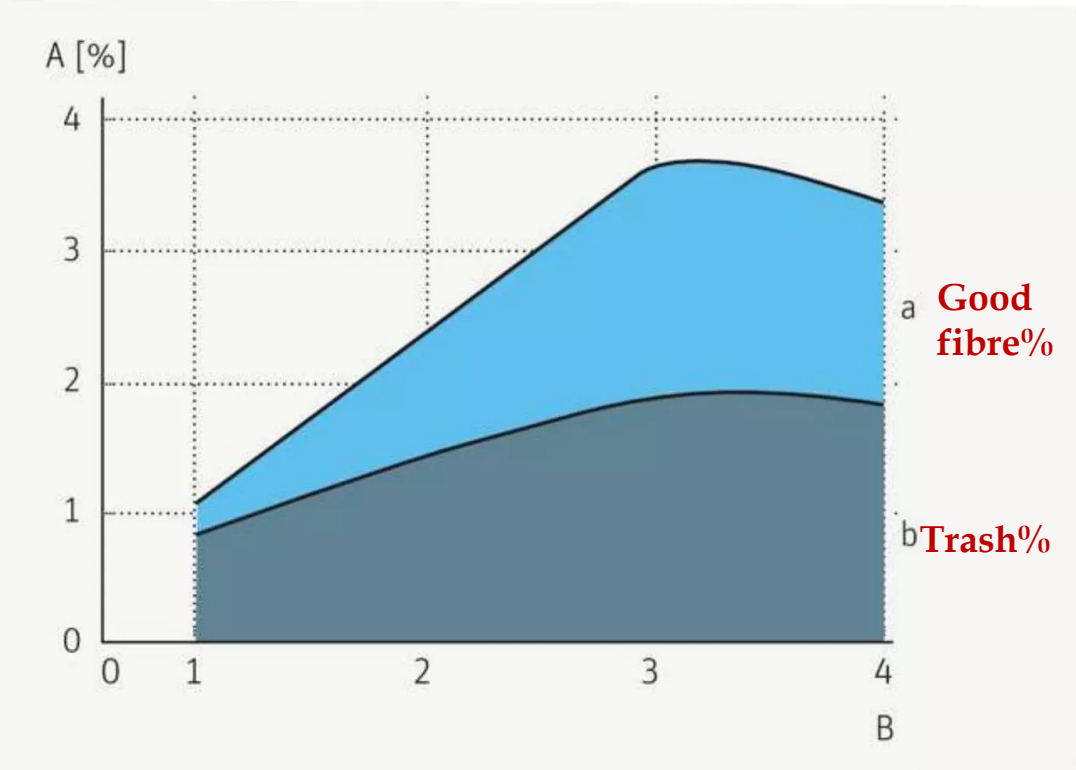
Effect of feed pedal distance



Waste % decreases with the increase in feed pedal distance

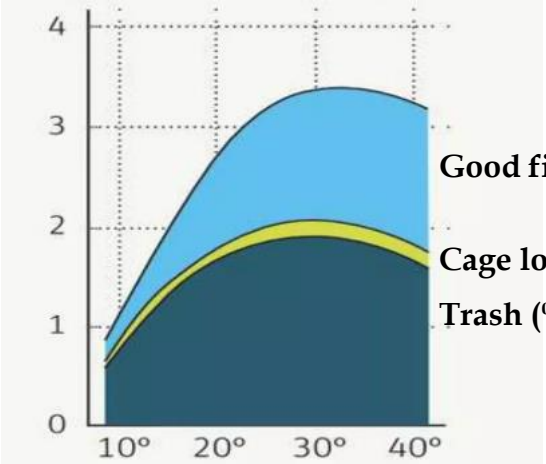
Parameters influencing waste level

Effect of grid bar opening

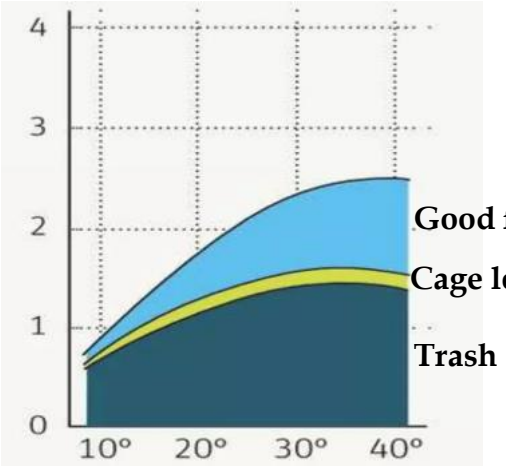


Grid bar opening

Effect of grid bar angle

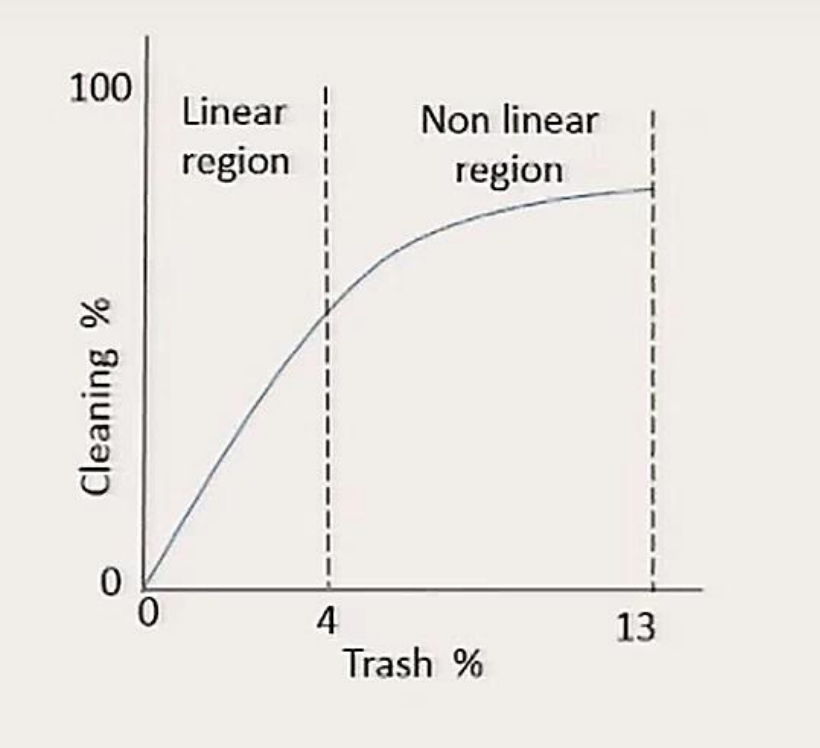


Higher beater speed



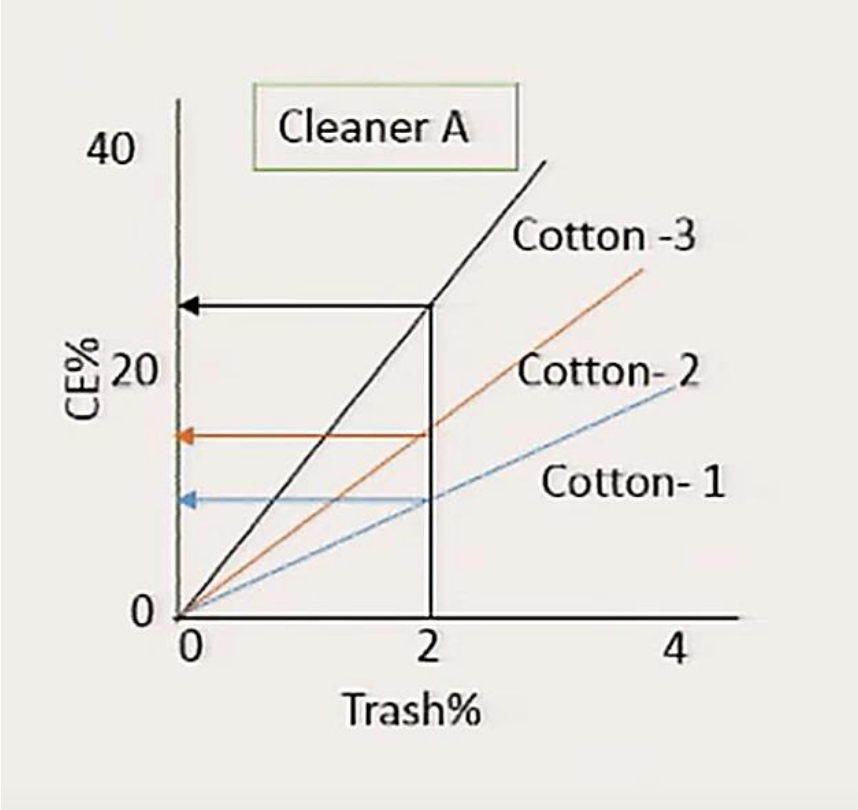
Parameters influencing waste level

Effect of trash% on cleaning



Why non-linear after 4% trash?

Effect of fibre type on cleaning



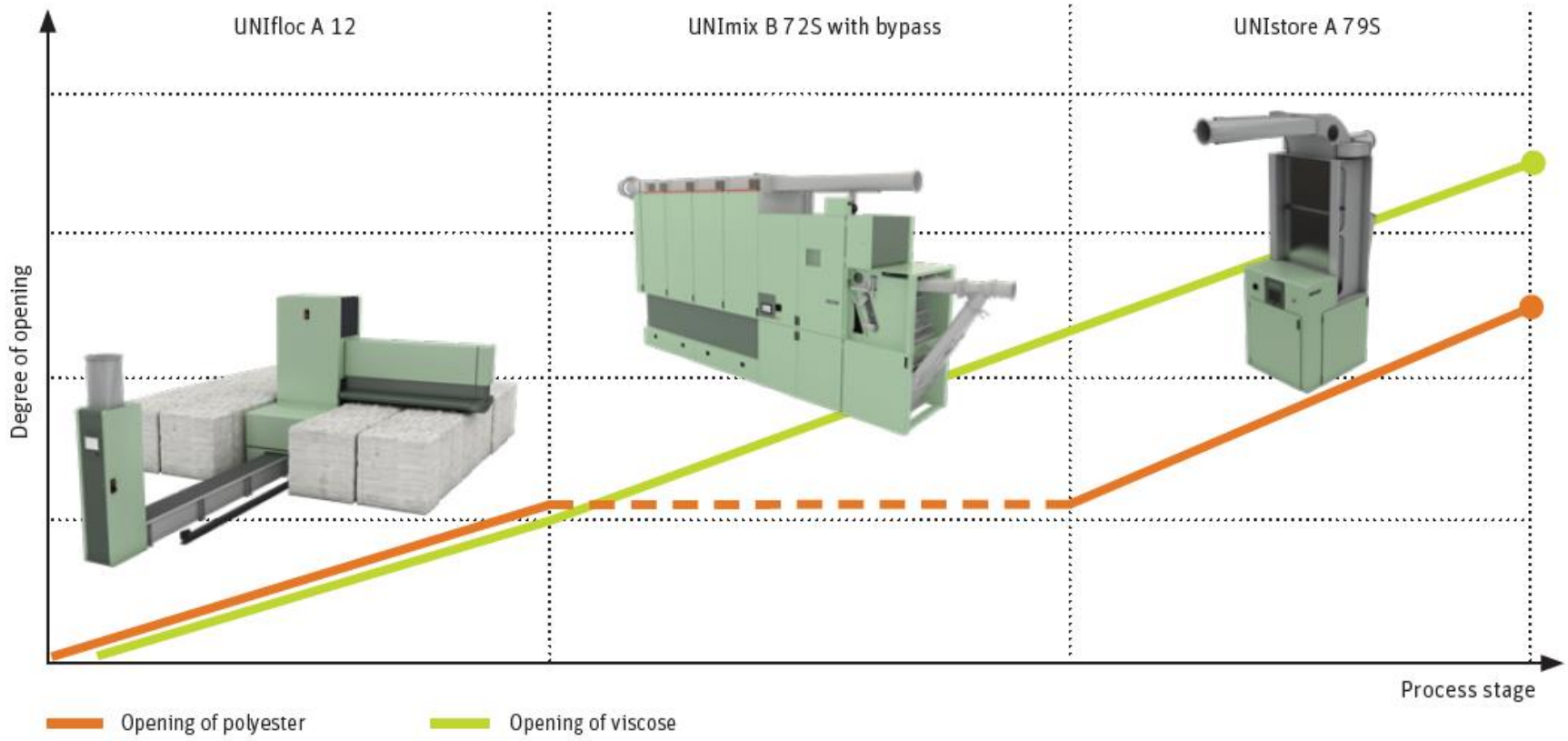
Cleaning resistance of cotton

Parameters influencing waste level

Problem: In a blowroom line, a fine cleaner gives cleaning efficiency of 24% for trash content in the feed of 4.3%. The amount of waste collected under the cleaner is 2.8%. Calculate the trash and lint% in the waste.

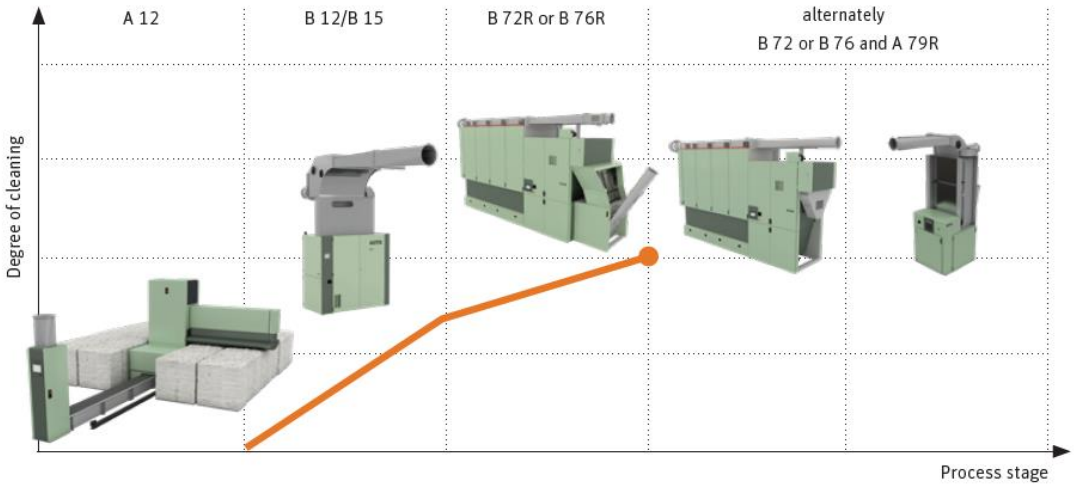
Ans: **Trash collected in waste: 40%**
Lint collected in waster: 60%

Cleaning of different fibre types

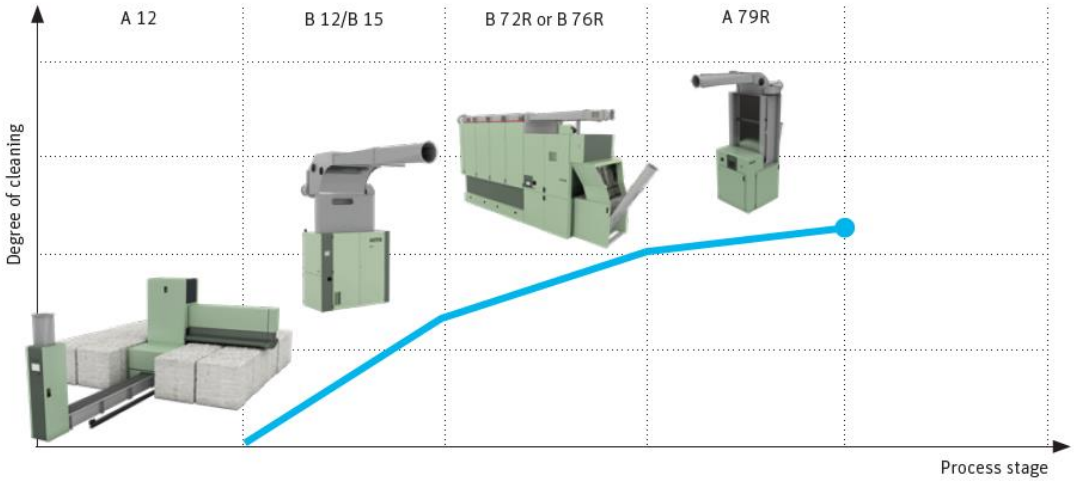


Cleaning of different fibre types

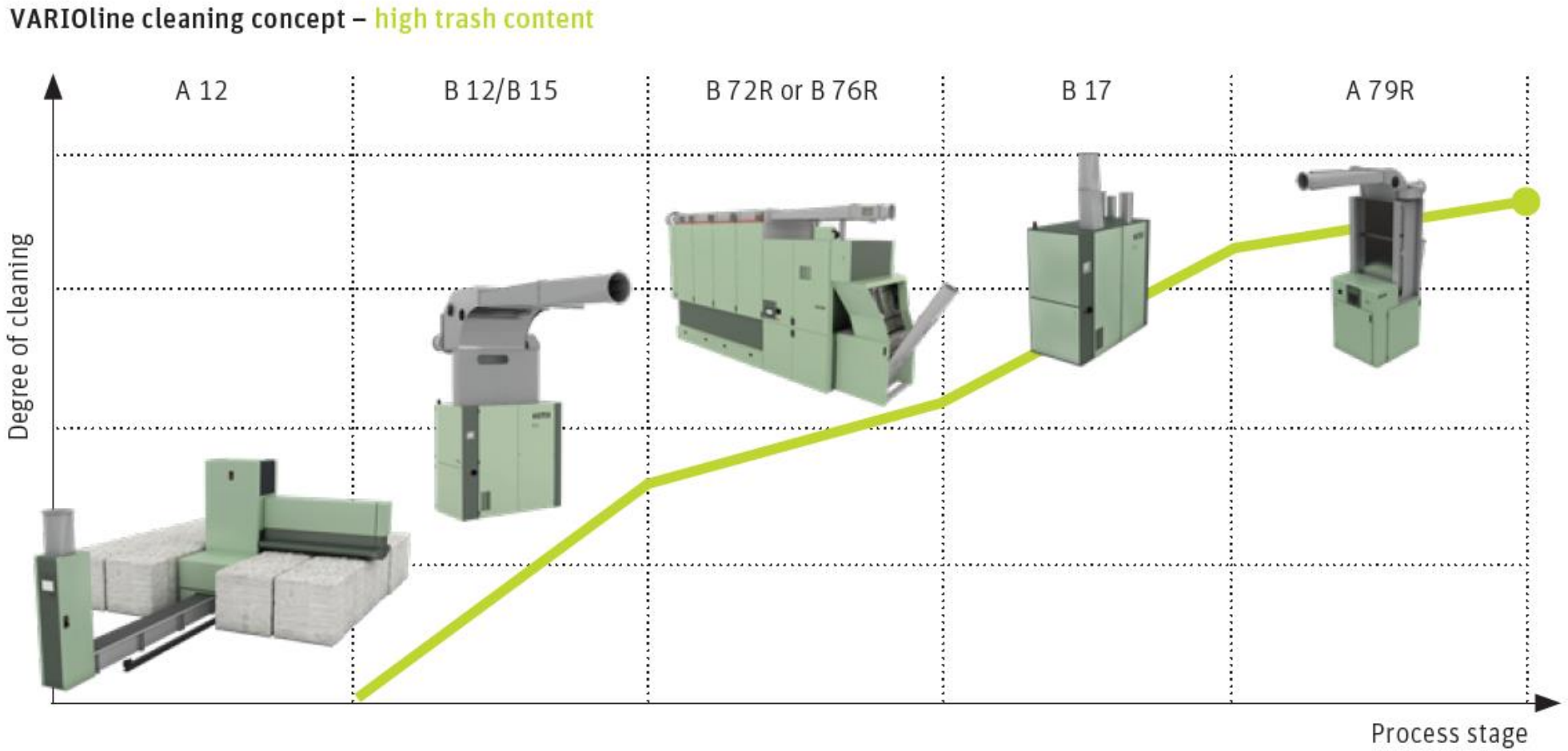
VARIOline cleaning concept – low trash content



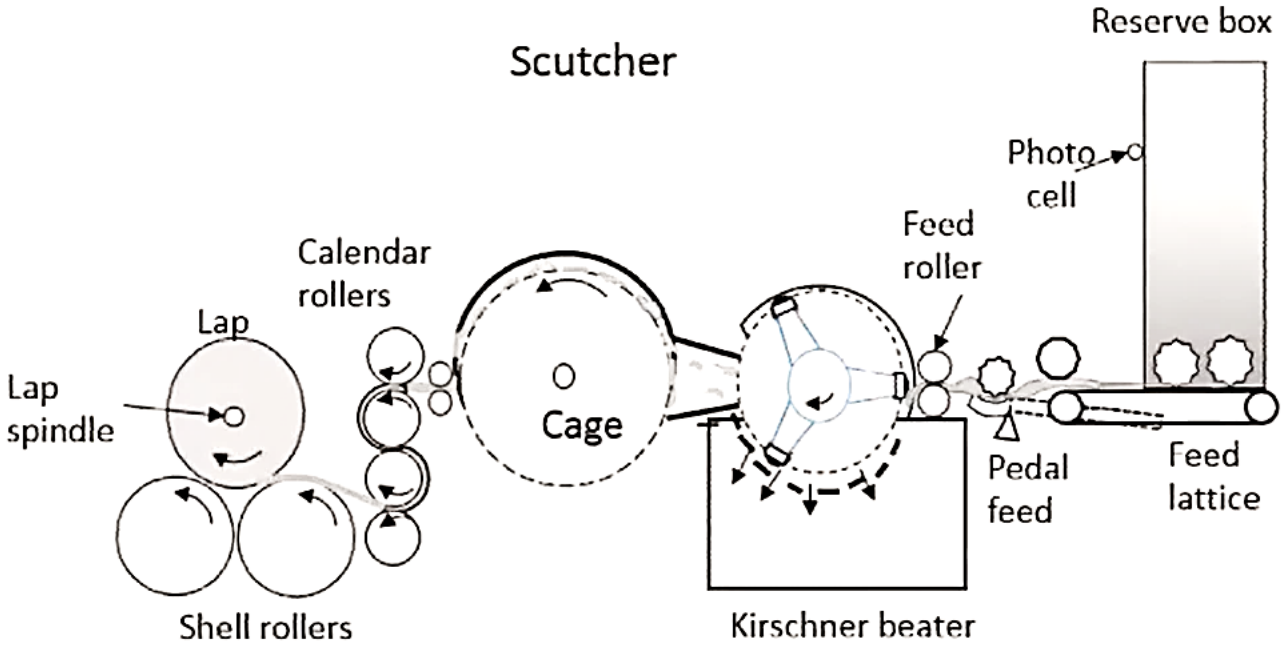
VARIOline cleaning concept – medium trash content



Cleaning of different fibre types



Lap Formation



No Scutcher in modern blowroom line:
Flock Feed system

- $Production(m) = delivery\ speed(m/\min) \times duration(min)$

- $Production(Kg) = Delivery\ speed(m/\min) \times duration(min) \times \frac{1}{1000} \times lap\ weight\ (g/m)$