Yarn Tensioning

The objective of yarn tensioning is to build a package with **adequate compactness**.

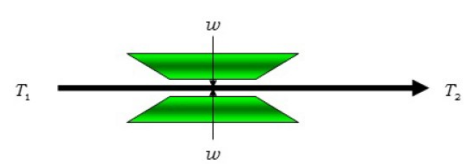
Higher yarn tension than the optimum will result in a **tighter package** and vice versa.

If there is any portion of yarn which is very weak then it will not be able to sustain the applied winding tension and as a result the **yarn will break**.

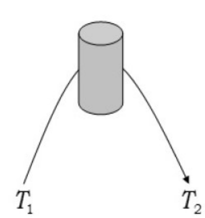
As a rule of thumb, yarn tension in winding is around **1 cN/tex .**

Types of Tensioning Device

1. Additive or disc type tensioner

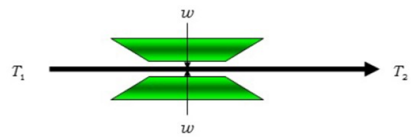


2. Multiplicative type tensioner



Additive type or disc type tensioner

Yarn is passed through two smooth discs one of which is weighted with the aid of small circular metallic pieces.



If T1 and T2 are the tension (cN) in the input and output yarns respectively, w is the weight (cN) applied on the top disc and μ is the coefficient of friction between the yarn and metal disc then

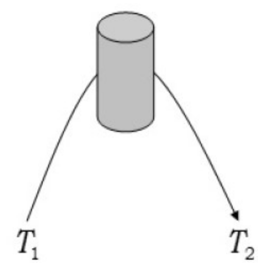
$$\boxed{T_2 = T_1 + 2\mu w}$$

Multiplicative type tensioner

Yarn is passed round a curved or cylindrical element

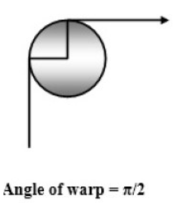
The relationship between input and output tension expressed as

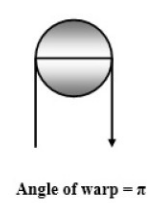
$$\boxed{T_2 = T_1 e^{\mu\theta}}$$



where θ is the angle of wrap (in radian) of the yarn around the tensioning element.

Two situations with angle of wraps of π and π/2



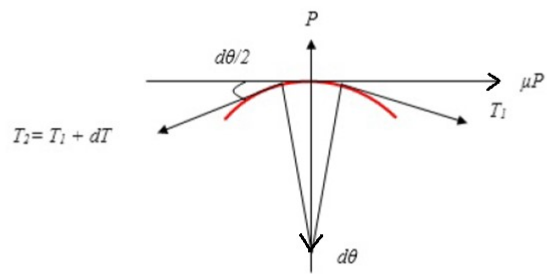


Relation between Input and Output Tensions in Multiplicative Tensioner

The yarn is passing over the curvature, shown in red color, which is considered to be part of a circle.

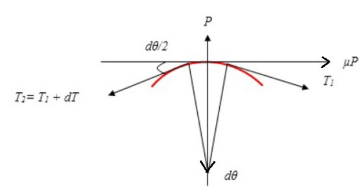
The contact region between the curvature and yarn has created a small angle dθ at the centre of the assumed circle.

The yarn tension in the input side is T1 and tension in the output side is T2. The difference between T2 and T1 is dT.



Relation between Input and Output Tensions in Multiplicative Tensioner

The difference between the horizontal component of T2 and T1 will balance the frictional resistance which will depend of coefficient of friction between the yarn and tensioner (μ) and the resultant vertical component of T2 and T1.



Resolving and balancing the vertical components

$$P = (T_1 + dT_1)\sin\frac{d\theta}{2} + T_1 \sin\frac{d\theta}{2}$$
$$\cong 2T_1 \sin\frac{d\theta}{2} \text{ (as } \frac{d\theta}{2} \text{ is small, } \sin\frac{d\theta}{2} = \frac{d\theta}{2} \text{ and product of } \frac{d\theta}{2} \text{ and } dT_1 \text{ can be ignored)}$$
$$\cong 2T_1 \times \frac{d\theta}{2} = T_1 d\theta$$

Relation between Input and Output Tensions in Multiplicative Tensioner

Resolving and balancing the horizontal components

$$\mu P = (T_1 + dT_1)\cos\frac{d\theta}{2} - T_1\cos\frac{d\theta}{2}$$

$$= dT_1\cos\frac{d\theta}{2} \cong dT_1 \text{ (as } \frac{d\theta}{2} \text{ is very small, } \cos\frac{d\theta}{2} \approx 1)$$

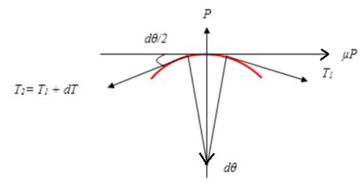
Now $\mu P = dT_1$

or, $\mu T_1 d\theta = dT_1$

or, $\mu\int_0^\theta d\theta = \int_{T_1}^{T_2}\frac{dT_1}{T_1}$

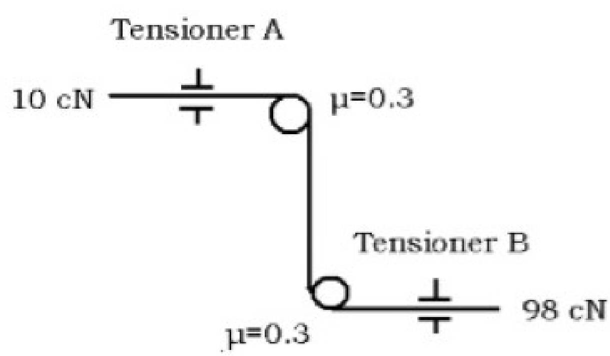
or, $\mu\theta = \log\frac{T_2}{T_1}$

or, $\frac{T_2}{T_1} = e^{\mu\theta}$



Numerical

1. The tensioning system shown in Figure is being used in a winding system. The input and output tensions are 10 cN and 98 cN respectively. If disc (additive) type tensioners A and B are identical then calculate the weights used in tensioners A and B



Numerical

Input tension = T_0 = 10 cN

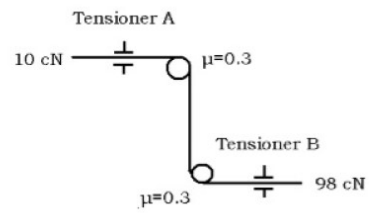
Tension in yarn after tensioner A= $T_1 = T_0 + 2\mu N = 10 + 2\mu N$

Tension after the first multiplicative tensioner = $T_2 = T_1 e^{\mu\theta}$

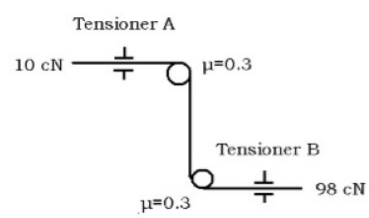
Here, $\theta = 90^0 = \frac{\pi}{2}$

Tension after the second multiplicative tensioner $= T_3 = T_2 e^{\mu\theta} = \left(T_1 e^{\mu\theta}\right) e^{\mu\theta}$
$= T_1 e^{2\mu\theta}$

Tension after tensioner B= $T_4 = T_3 + 2\mu N$
$= T_1 e^{2\mu\theta} + 2\mu N$



Numerical



Now $= T_1 e^{2\mu\theta} + 2\mu N = 98$

$or,\ (10 + 2\mu N)e^{2\mu\theta} + 2\mu N = 98$

$or,\ (10 + 0.6N)e^{0.3\pi} + 0.6N = 98$

$or,\ 2.56\,(10 + 0.6N) + 0.6N = 98$

$or,\ N = 33.9 \approx 34$

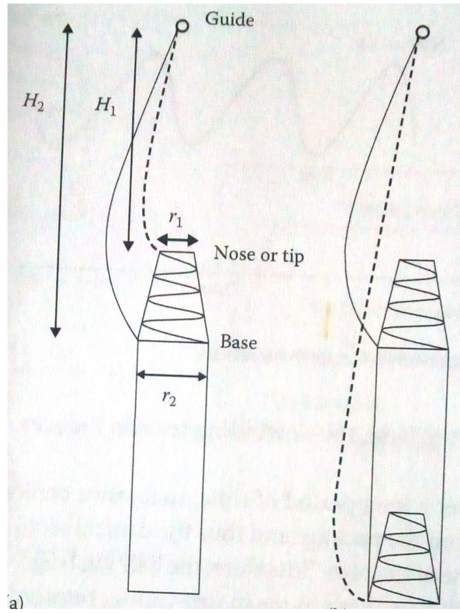
So, the weight of each of the discs is 34 cN.

Tension Variation During Unwinding from Cop Build Package

During unwinding of yarns from cop build packages (ringframe bobbin, pirn etc) short term and long term tension variation is noticed.

Short term tension variation arises due to movement of yarn from tip to base and vice versa.

Long term tension variation occurred due to the change in height of balloon formed between unwinding point and yarn guide



Tension Variation During Unwinding from Cop Build Package

The empirical equation for unwinding tension is given below.

$$\text{Unwinding tension} = mv^2\left[C_1 + C_2\left(\frac{H}{r}\right)^2\right]$$

where H is balloon height

r is package radius (varies between tip and base)

m is mass per unit length of yarn

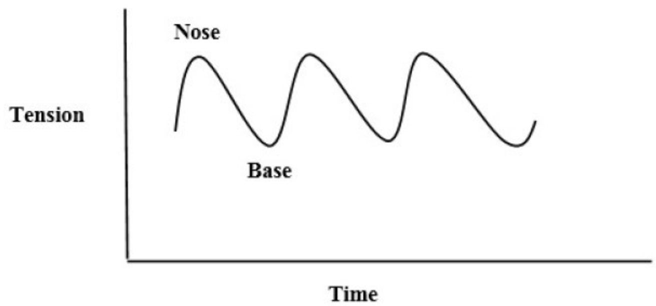
V is unwinding speed

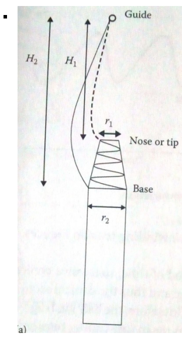
Tension Variation During Unwinding from Cop Build Package

Short term tension variation: one layer of coil is unwound and yarn withdrawal point moves from tip to base

Both the H and r increase. However, **proportionate change in r is higher as compared to H.**

Therefore, in every cycle, when the withdrawal point moves from **tip to base**, the **unwinding tension reduces**.

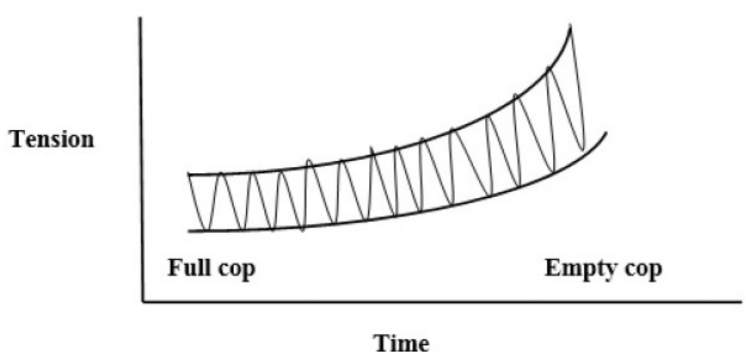


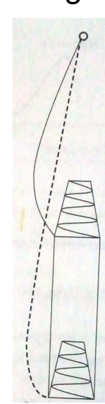


Tension Variation During Unwinding from Cop Build Package

Long term tension variation: successive conical layers of yarns are removed from the package and thus the conical section of yarns move **towards the base** of the pirn.

Therefore, the **balloon height increases** resulting in progressive **increase in mean unwinding tension**.





Yarn Clearing

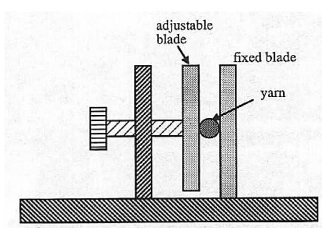
The objective of yarn clearing is to remove **objectionable faults (and not imperfections)** from the supply package.

objectionable faults: Only those faults which have potential to disrupt the subsequent operations or spoil the fabric appearance.

Imperfections: Frequently occurring like Thick places, thin places and neps

Yarn Clearing: Principles of Measurement

1. Mechanical yarn clearer

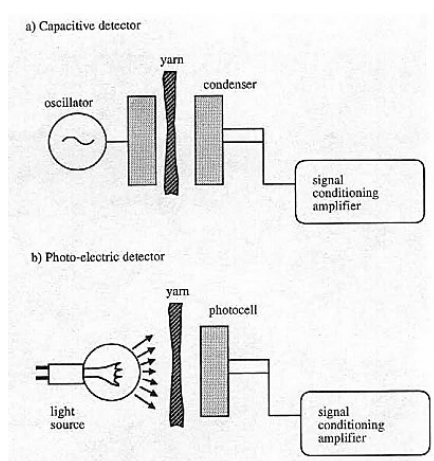


2. Capacitance principle

measurement of yarn mass at given test length

3. Optical principle

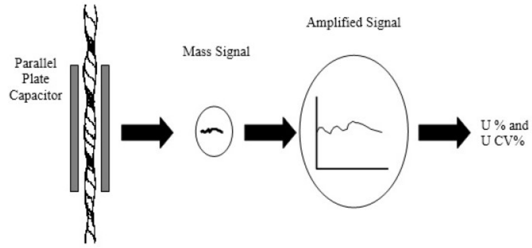
diameter measurement



Yarn Clearing: Capacitance principle

The yarn is passed at a constant velocity through two parallel plate capacitors

Change in mass per unit length measured in terms of capacitance values



$$\text{Capacitance} = C = \frac{\varepsilon A}{d} = \frac{k\varepsilon_0 A}{d}$$

where A is area of plates, d is distance between plates, ε is permittivity of medium present between places, ε_0 is permittivity of vacuum and k is dielectric constant of medium.

Yarn Clearing: Capacitance principle

When the yarn will pass through the parallel plates, the equation will take the following form.

$$C = \frac{A}{\left(\frac{d_1}{\varepsilon_1} + \frac{d_2}{\varepsilon_2}\right)} = \frac{A\varepsilon_0}{\left(\frac{d_1}{k_1} + \frac{d_2}{k_2}\right)}$$

where d_1 is the thickness of material 1 (yarn)

d_2 is the thickness of material 2 (air)

ε_1 is the permittivity of material 1

ε_2 ($\approx \varepsilon_0$) is the permittivity of material 2

k_1 is the dielectric constant of material 1

k_2 is teh dielectric constant of material 2

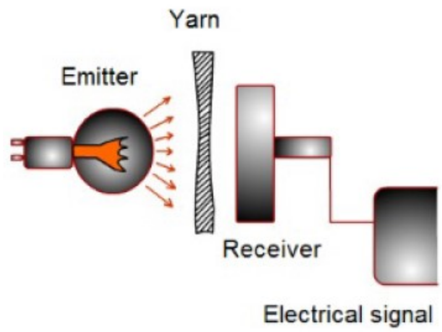
Limitation: Measurement is highly sensitive to presence of moisture

Yarn Clearing: Optical principle

The emitter emits light and the receiver detects it and converts to proportional electrical signal.

The light received by receiver depend on diameter of yarn passing between emitter and receiver.

Higher yarn diameter result into reduced amount of light received by the receiver.

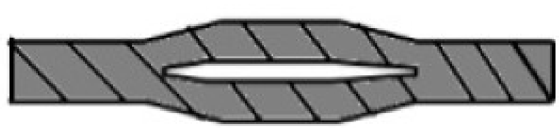


Yarn Clearer comparison

For circular yarn cross-section, **mass is directly proportional to diameter^2**

Therefore, **capacitance based measurements are more sensitive** to deviation than optical based measurements

Some of the faults **(hole within yarn structure)** are not detected by capacitance based testers, but can be detected by optical type testers.



Yarn faults

Yarn blemishes are broadly categorized under two heads

1. **Frequently occurring or yarn imperfections**

- Do not cause serious threat to the subsequent processes or fabric appearance

2. **Seldom occurring or objectionable yarn faults**

- Adversely affect subsequent processes due to frequent breakage and severely damage fabric appearance

Yarn Imperfections

Occur very frequently in the spun yarns, but, do not pose serious threat to the subsequent processes or fabric appearance.

Measured by yarn unevenness testers and expressed by the frequency of occurrences per km.

1. Thick places (mass exceeds by at least + 50% of the nominal mass)
2. Thin places (mass is lower than by at least - 50% of the nominal mass)
3. Neps (mass exceeds by + 200% of the nominal mass with reference length of 1 mm)

Objectionable Yarn Faults

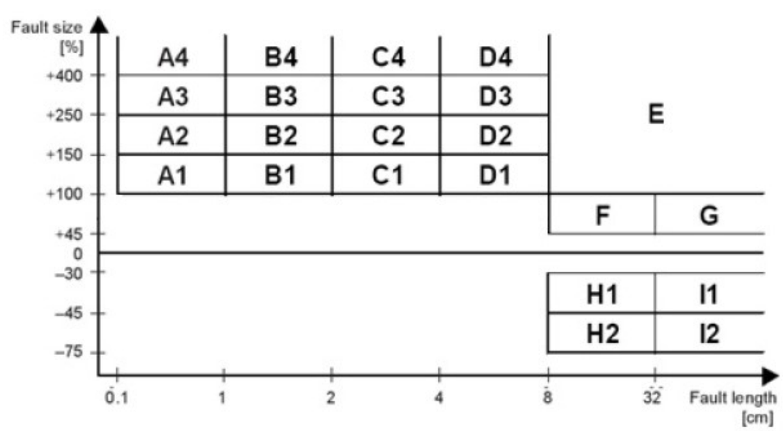
Seldom occurring mass variation in the yarn.

Adversely affect the running performance of the loom due to frequent breakage and severely damage the appearance of the fabric.

Yarn faults are tested by **Classimat III (23 classes) or Classimat IV (33 classes) or Classimat V (45 classes)** testers depending on the **length and diameter** of the faulty place.

Yarn faults generally expressed by the number of occurrences per 100 kilometers.

Classimat III



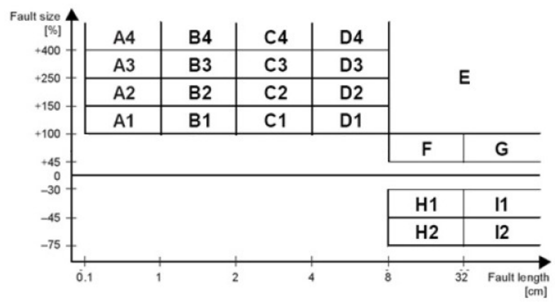
1. **Short thick faults: A1 to D4**
2. **Long thick faults: E, F and G**
3. **Long thin faults: H1, I1, H2, I2**

Classimat III

The classifications A, B, C, and D correspond to fault reference lengths of 0.1-1, 1-2, 2-4 and 4-8 cm respectively.

The sensitivity % indicates percentage increase in the fault mass varying from +100% to more than +400%, corresponding to diameter increase of 41% and 123%.

This results in 16 classifications with A1 the shortest in length and smallest in diameter and D4 the longest in length and largest in diameter.

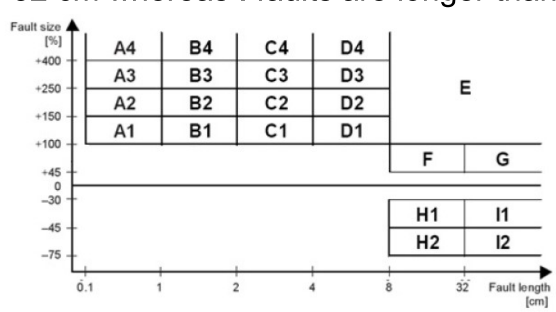


Classimat III

Spinners' double refer to a long thick fault (with the indication E) whose length overstep 8 cm and mass exceeds +100%.

F and G are also long thick faults as their mass exceeds the nominal level by + 45% and length is between 8-32 cm and greater than 32 cm respectively.

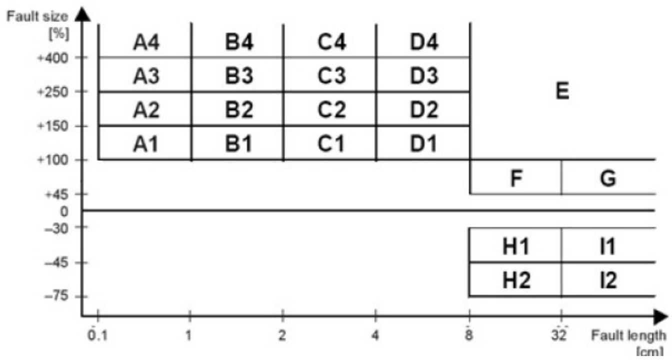
Within the long thin category, H faults are having length between 8-32 cm whereas I faults are longer than 32 cm.



Classimat III

A4, B4, C4, D4, C3 and D3 are generally considered as objectionable faults

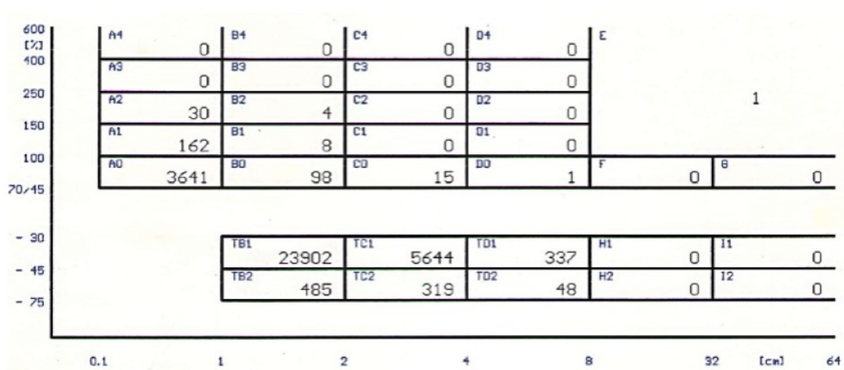
Now, A3, B3, C2 and D2 are also considered as objectionable faults for high quality products.



Classimat IV faults

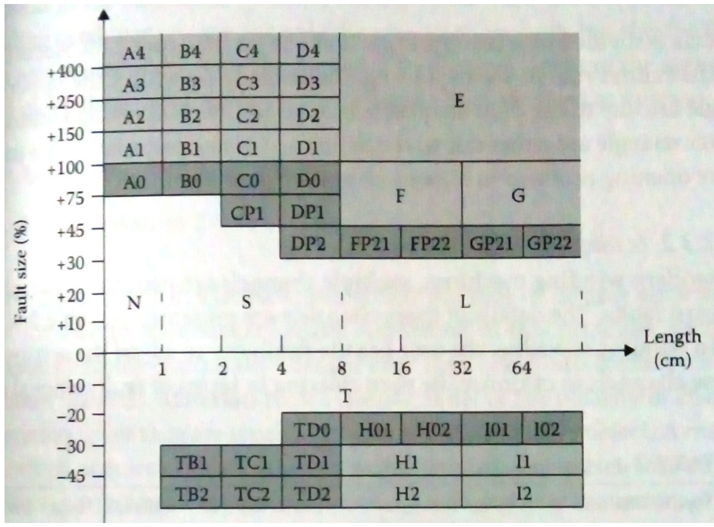
In addition to the 23 faults of Classimat III, there are 10 additional faults (total 33 faults)

- ➢Very short thick fault (A0, B0, C0 and D0)
- ➢Short thin faults (TB1, TC1, TD1, TB2, TC2, TD2)



Classimat V faults

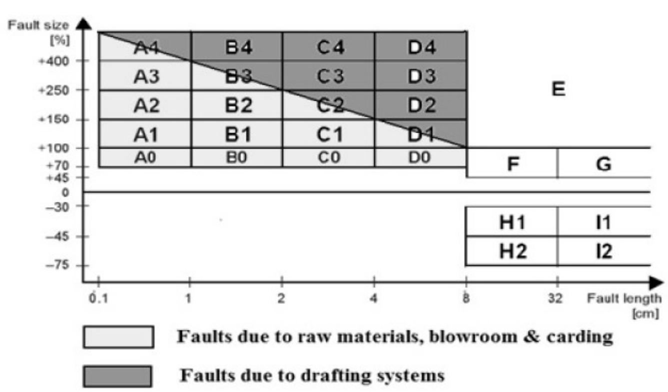
Total 45 fault categories



Causes of Classimat Faults

The short thick faults (A1-D4) are caused by raw material defects and preparatory stages or due to drafting defects.

Faults lying within the upper diagonal are due to the drafting faults whereas the faults lying below the diagonal are either due to the deficiency in the raw material.



Removal of Foreign and Colored Fibres

➢The contamination includes jute, polypropylene, husk, leaf, hair and paper.

➢The electronic yarn clearers in modern winding machines not only remove the objectionable faults but removes the foreign and coloured fibres also.

➢Some of the systems used to remove foreign fibres are given below:

1. Loepfe Zenit Yarn Master ® (Tribo-electric effect)
2. Uster Quantum 2 (Image analysis)