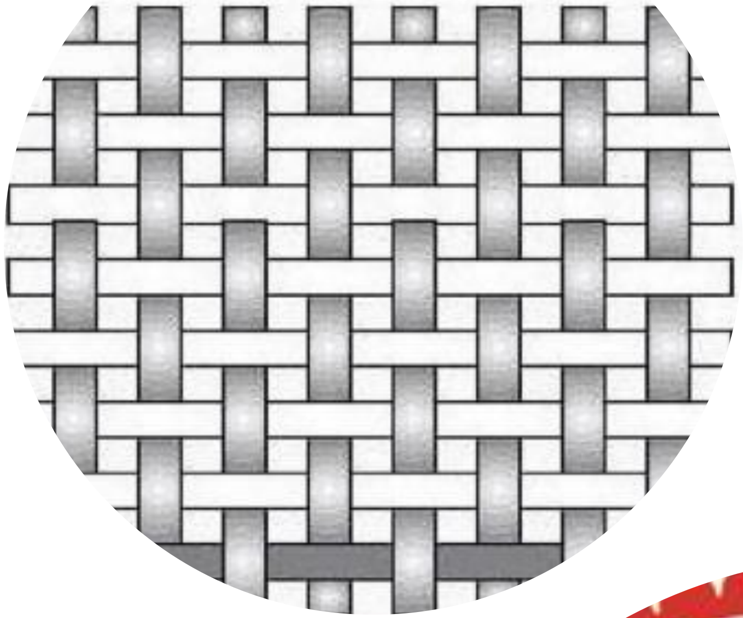
Fabric Manufacturing I (TXL231)



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Sizing: Drying zone

The drying operation is very crucial because of the following reasons.

- It consumes most of the energy of sizing process
- Inadequate drying will cause sticking of yarns with one another causing problem in weaving
- Over-drying will make the size film brittle and therefore they may fall apart by minimum abrasion.

Mass (kg) of water to be evaporated per unit oven dry mass (kg) of yarn

$$= \left(\frac{\text{Add on \%}}{\underbrace{\text{Concentration \%}}_{\text{wet pick-up}}}\right) - \left(\frac{\text{Add on \%}}{100}\right)$$

This equation presumes that there is no residual moisture in the sized yarn after drying

For a running machine it is important to calculate the mass of water to be evaporated in unit time (minute)-

- Sizing machine speed
- Total number of yarns
- Linear density of yarns (Tex)
- Add-on %
- Concentration %

Sizing: Drying zone

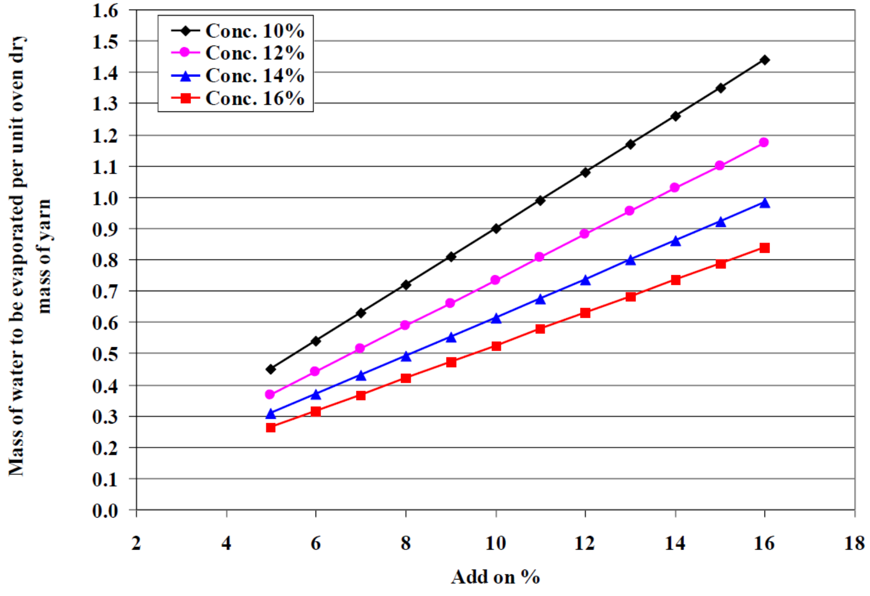
The mass of yarn passing through the machine per minute

$$= \frac{\text{Sizing machine speed (m/min)} \times \text{Total number of yarns} \times \text{tex}}{1000 \times 1000} \text{ kg}$$

The mass of size paste pick up per minute

$$= \left(\frac{\text{Sizing machine speed (m/min)} \times \text{Total number of yarns} \times \text{tex}}{1000 \times 1000} \times \text{wet pick up} \right) \text{kg}$$

$$= \left(\frac{\text{Sizing machine speed (m/min)} \times \text{Total number of yarns} \times \text{tex}}{1000 \times 1000} \times \frac{\text{add on \%}}{\text{concentration \%}} \right)$$



The mass of water to evaporated per minute

$$= \frac{\text{Sizing machine speed (m/min)} \times \text{Total number of yarns} \times \text{tex}}{1000 \times 1000} \times \frac{\text{add on \%}}{\text{concentration \%}} \times \left(1 - \frac{\text{Concentration \%}}{100} \right) \text{kg}$$

Both sensible heat and latent heat to be considered here-

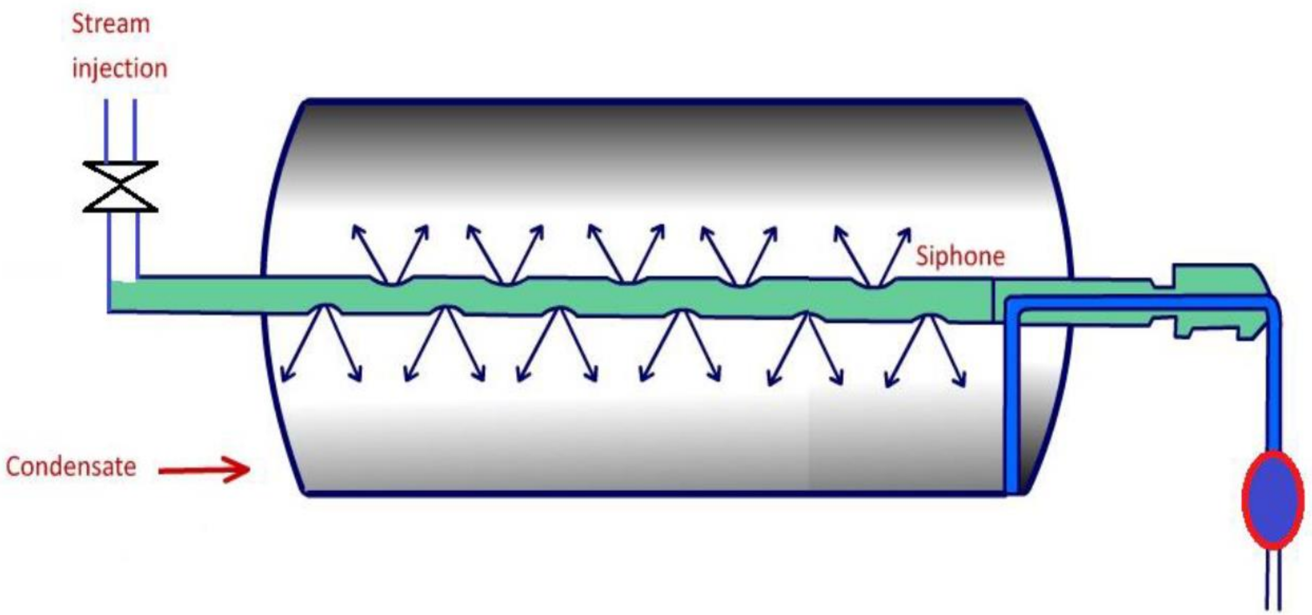
1. **Sensible- to raise the yarn temperature up to water evaporation**
2. **Latent- For the actual evaporation**

Sizing: Drying zone

The methods of drying in sizing process can broadly be divided in two categories-

1. Conduction
2. Convection

In **conduction method** the warp sheet is passed over a metallic cylinder which is heated by using superheated steam. Heat exchange takes place between the wet warp sheet and heated cylinders and in the process the warp sheet is dried

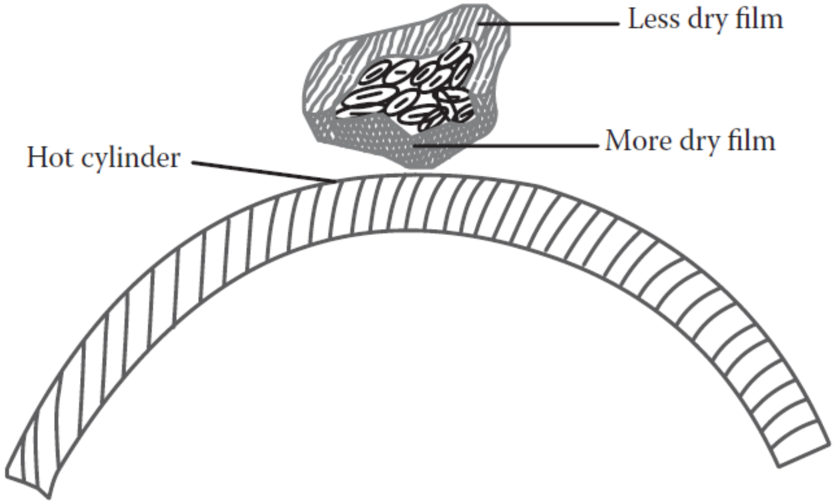


$Q' = kA(dT/dx)$

Sizing: Drying zone

Some issues with this method-

- Part of the heat energy of steam/gas is spent in heating the metallic cylinder up to the required temperature
- Direct contact between a size film– coated yarn sheet and the hot cylinder causes a localized instantaneous drying of the portion touching the cylinder. This causes a moisture gradient



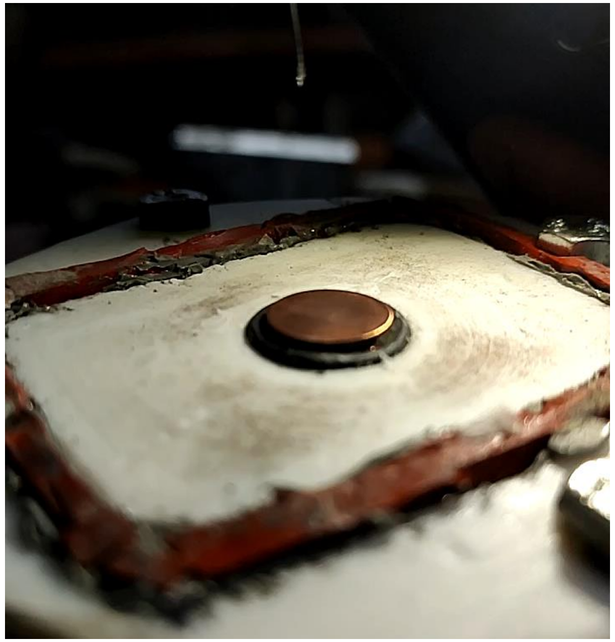
Alternative-

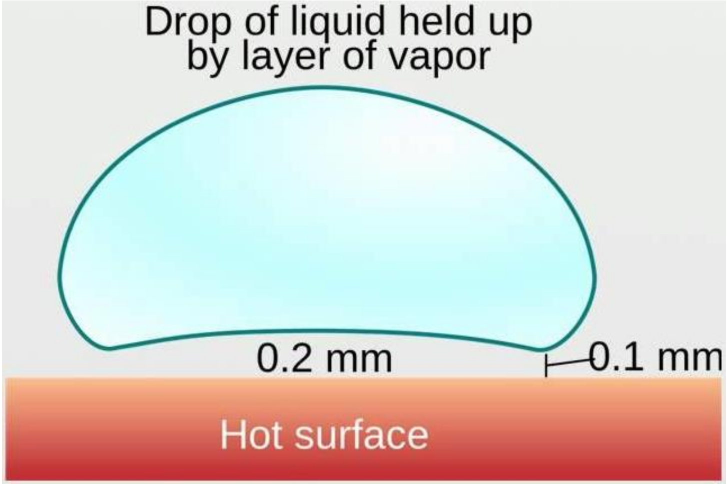
- Dry the two sides of yarn alternately in many small steps, a strategy adopted in multicylinder drying systems (eight cylinders arranged in two blocks of four)
- The wet yarn sheet is initially split into two layers while entering the first block (pre-drying) and then rejoined again in next block)

Sizing: Drying zone

Wet-splitting is preferred, because-

- A continuous coat of size film develops around each yarn
- If the yarns are fully dried in this state, then the subsequent splitting zone would become redundant
- Sufficient space between two adjacent yarns lowers the vapor pressure, thereby facilitating evaporation and helps in avoiding steam blanket





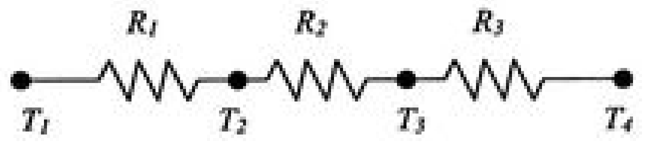
Sizing: Drying zone

At the instant of detachment of the warp sheet from the first drying cylinder, the size film surrounding each yarn would still be wet and soft, else it will get brittle locally and peel off.

The first few drying cylinders are coated with PTFE (polytetrafluoroethylene), because-

1. Very low coefficient of friction of PTFE
2. High thermal stability
3. Low thermal conductivity (1/100th of steel but 10 times of air)

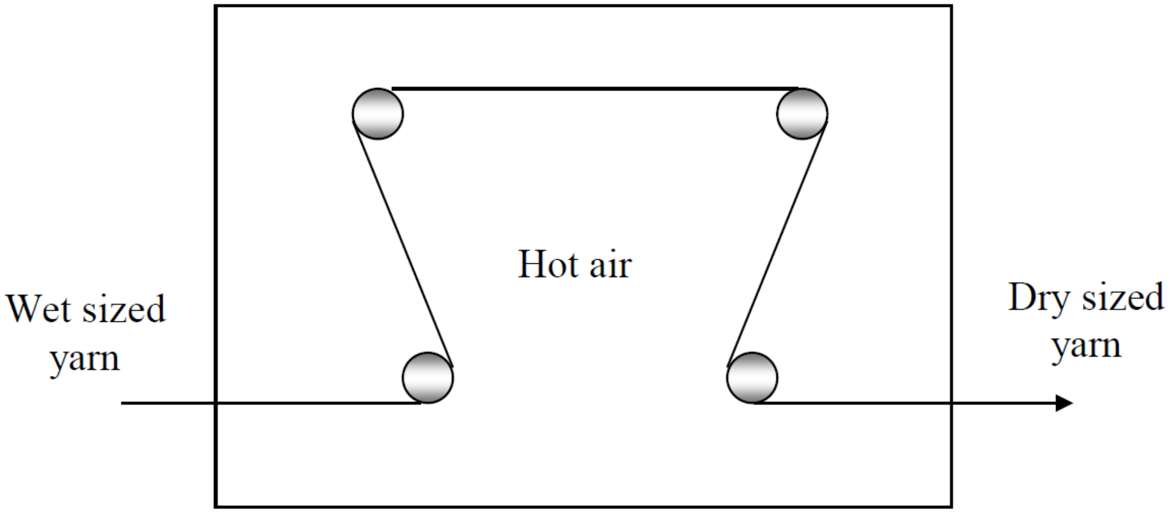
But the thermal energy of steam injected into the cylinder is wasted considerably in overcoming the combined resistance of a layer of condensate on the inner wall of the cylinder, the wall of the cylinder itself, and the layer of PTFE.



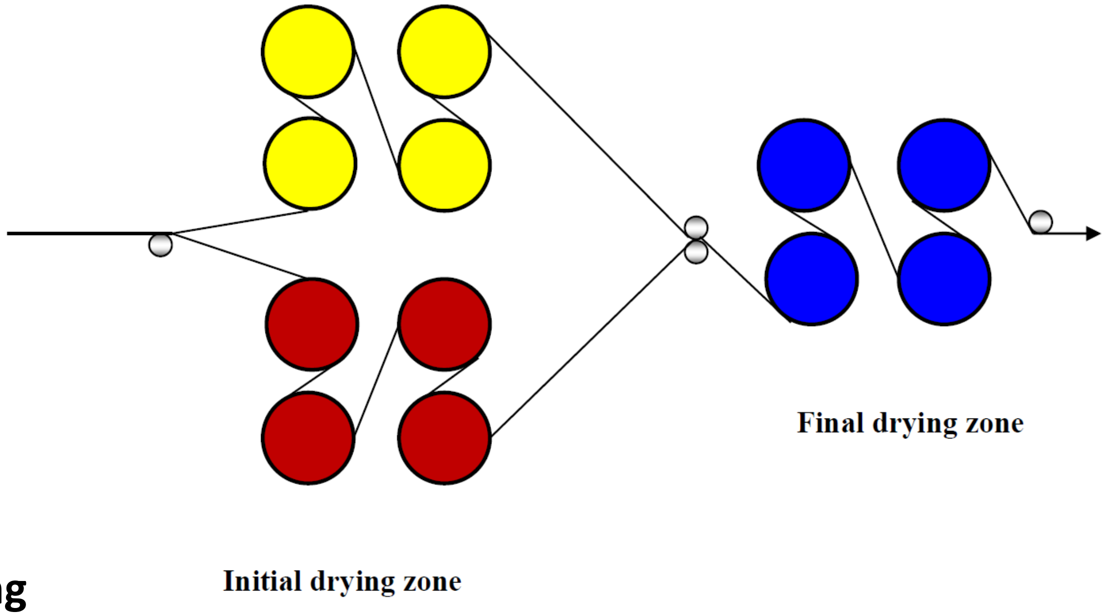
Can be overcome with hot air

Sizing: Drying zone

Convection system



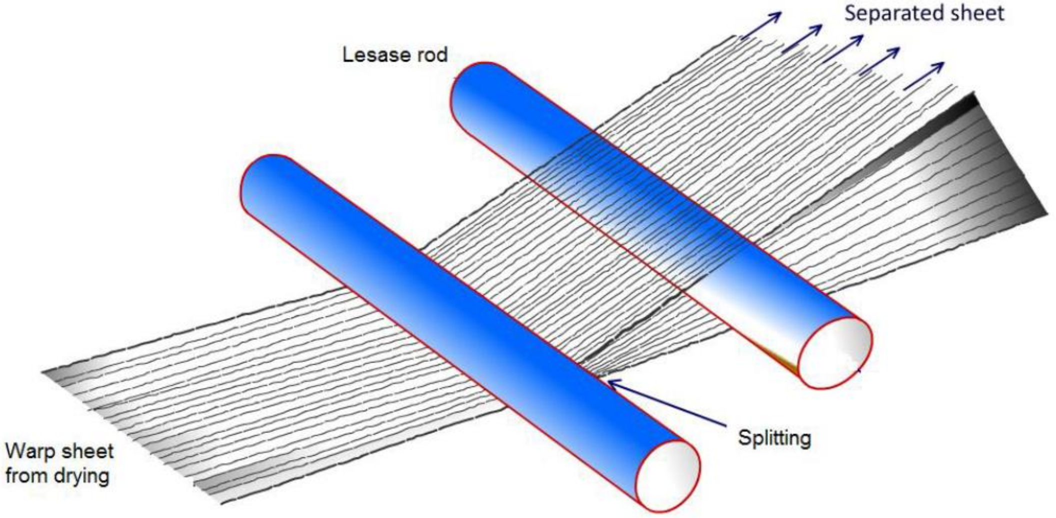
Q’= hAdT



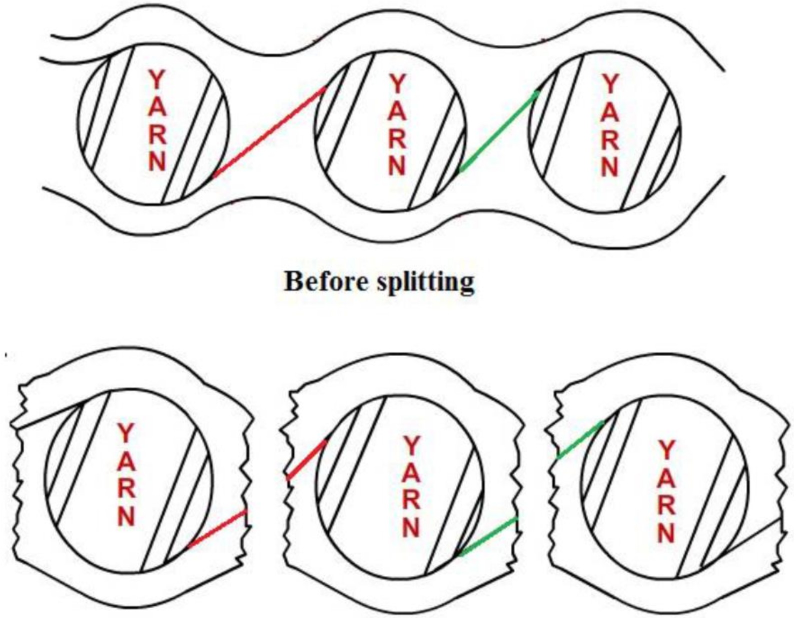
Two-zone drying

Sizing: Splitting

Splitting of warp sheet



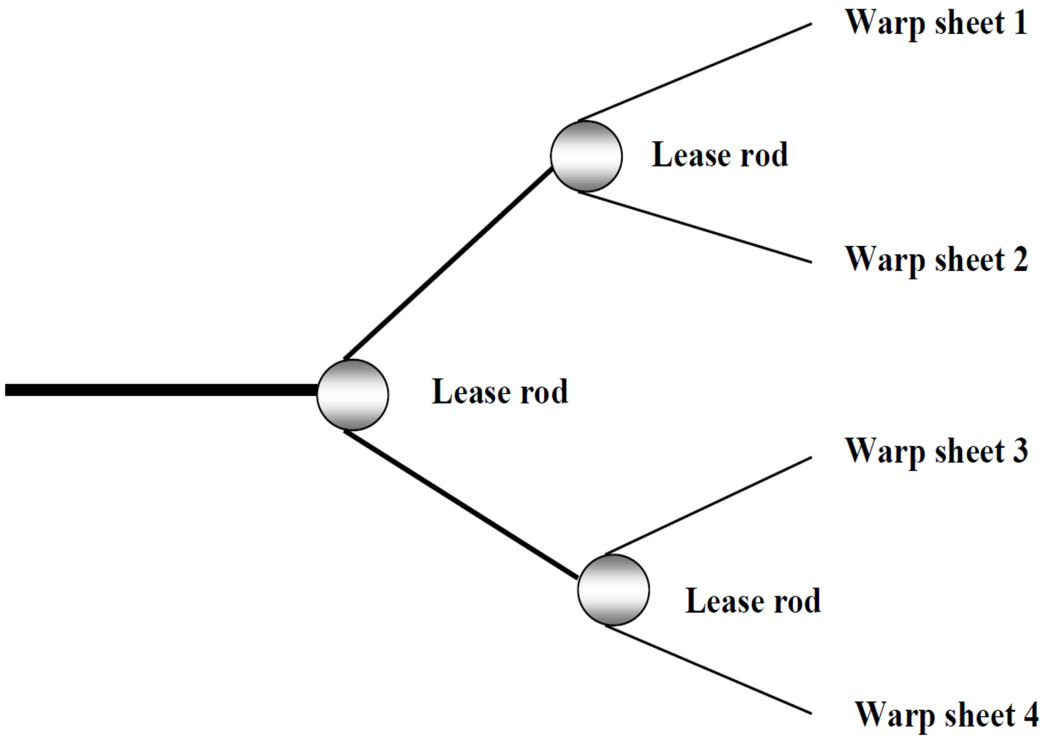
Function of lease rods is to separate the individual yarns which are stuck together by dried size. During the splitting some amount of size film would be dropped as waste. However, many longer fibres, bridging two adjacent yarns would also get broken into smaller pieces.



Before splitting

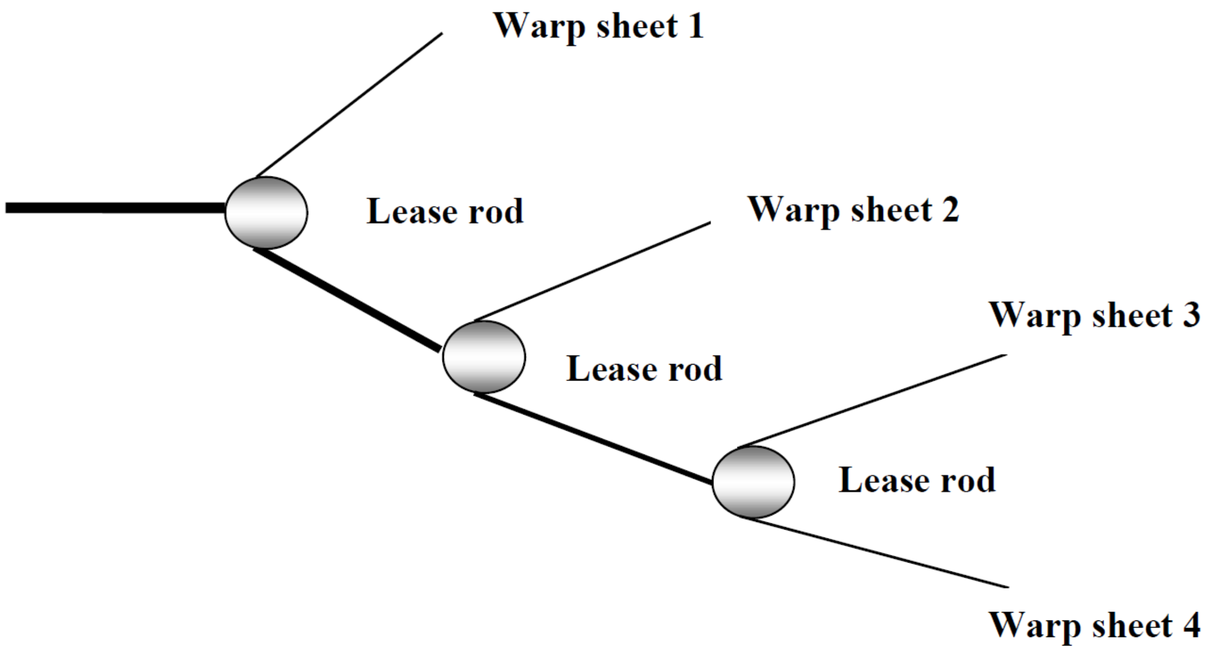
After splitting

Sizing: Splitting



Splitting of sized warp sheet into equal parts

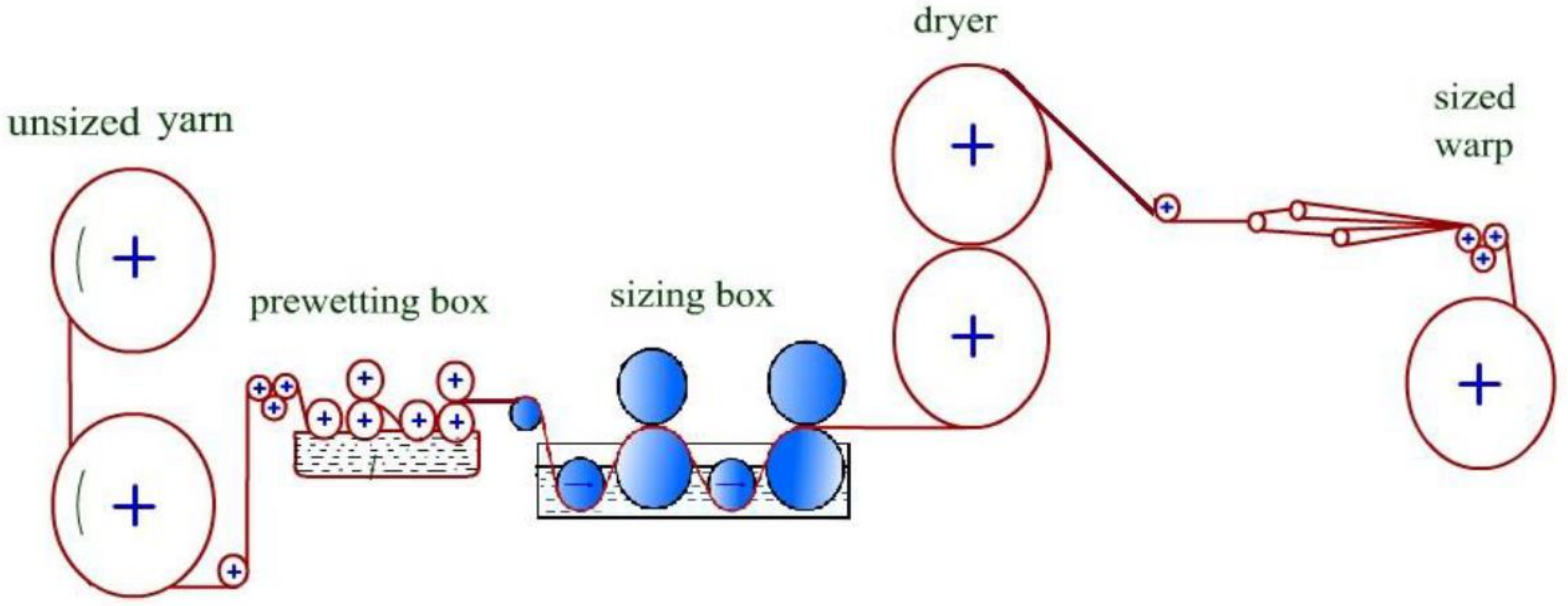
Splitting of sized warp sheet into unequal parts



Sizing: With pre-wetting

The advantages of pre-wetting are-

- Reduction of size ingredient consumption up to 50%
- Increase in yarn strength
- Reduction of yarn hairiness
- Improvement of loom efficiency



Sizing: Example problem

A 40 tex cotton yarn has add-on of 8%. If the moisture regain of the warp is 10% then determine the oven-dry mass of the size added per kg of the unsized warp.

Size add-on = 8%, Moisture regain = 10%

So, $\frac{W}{D} \times 100 = 10$, where W= mass of water and D = oven dry mass of yarn

or, $W = 0.1D$

Let, total mass of unsized yarn = 1 kg

So, $D+W$ = 1 kg, or, $D+0.1D$ = 1 kg

or, D = 0.909 kg

Now, add-on is 8%.

$$\text{So, } \frac{\text{Oven dry mass of size}}{\text{Oven dry mass of yarn } (D)} \times 100 = 8$$

or, Oven dry mass of size = D x 0.08 = 0.073kg = 73 g.

So, oven dry mass of size per kg of unsized warp is 73 gram.

Sizing: Example problem

A sizing machine is running at 150 m/min with 6000 ends. The add-on requirement is 12% and concentration of the size paste is 18%. If yarn count is 20 tex (without any moisture) and residual moisture content in the sized yarn and film after drying is 10%, then calculate the number of drying cylinder required. One drying cylinder can evaporate 4 kg water per min.

$$\text{Oven dry mass of warp passing through the machine / min} = \frac{150\times 6000\times 20}{1000\times 1000}\ \text{kg} = 18\ \text{kg}$$

$$\text{Wet pick up }(WPU) = \frac{\text{Add on \%}}{\text{Concentration \%}} = \frac{12}{18} = 0.667$$

Total mass of size paste picked up by the warp= $WPU \times$ Oven dry mass of warp

$$= \frac{12}{18}\times 18\,\text{kg} = 12\ \text{kg}$$

Oven dry mass of size = Mass of size paste ×concentration = 12 ×0.18

Total oven dry mass of warp and size = (18 + 12×0.18+) kg = 20.16 kg

For moisture content of 10%, mass of water to be retained in warp and size film

$$= \frac{1}{9}\times 20.16\,\text{kg} = 2.24\ \text{kg}$$

$$\text{Mass of water in picked up size paste of 12 kg} = 12\times\left(\frac{\text{100-Concentration\%}}{100}\right) = 9.84\ \text{kg}$$

So, water to be evaporated per minute = (9.84 - 2.24) kg = 7.6 kg

Drying capacity of one cylinder = 4 kg/min.

Number of cylinders will be = 7.6/4 ≈ 2.