Basic principles of pad dyeing

Machinery requirements

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Padding

Fabric requirements after pre-treatment

- Uniform weave (no tight or dense selvedge's, consistent yarn density)
- Dry
- Fabric conditioning before dyeing (temperature, moisture content)
- Good absorbency
- Neutral reaction (pH 6 – 7)
- Free from size, bleaching chemicals, earth metals & salts (Fe, Ca, Mg)

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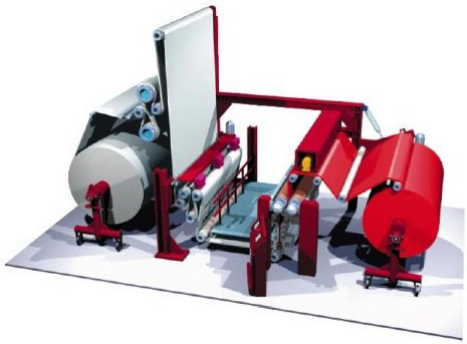

Padder

- pad roll shore hardness: 70 - 80° woven fabric, 50 - 60° knitgoods
- side-to-side pressure control, uniform nip across the width
  (Küsters Swimming Roll or Benninger Bicoflex system)
- synchronised fabric guidance - in feed / take up
- small volume pad trough with liquor level control (3 - 5 min turnover)
- even dye liquor distribution across the width
- speed and temperature control

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Fabric in-feed

Open width fabric must be processed under uniform tension, before entering the padder and during take-up on the beam.

Synchronised cloth guidance systems must be used

Incorrect tension or inadequate cloth guidance, causes:

- **Creases or twists in the fabric**
- **Piece-to-piece shade variation**
- **Side-centre shade variation**
- **Interruptions in production**

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Nip rolls

- Nip rolls must be clean and within hardness specification of 70 - 80° shore for woven and 50 - 60° shore for knitted fabric
- Damage to the nip rolls results in poor appearance of the dyed fabric and pick-up variations (silicate build up, age deterioration)
- The covering of both bowls must be of uniform hardness to prevent two sided problems

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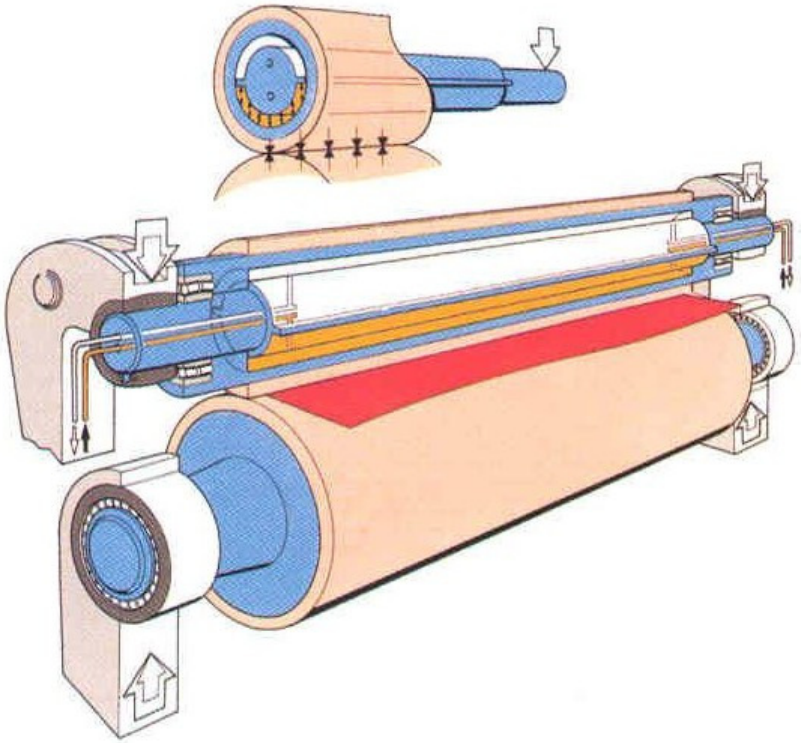
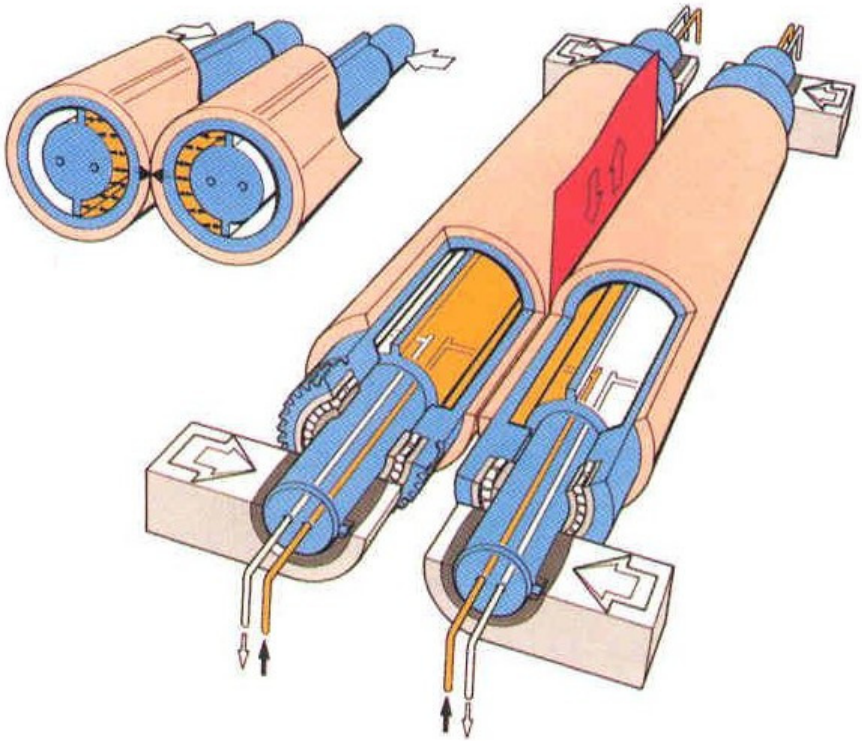
Küsters S-Roll

KÜSTERS

Single swimming roll:



Double swimming roll:



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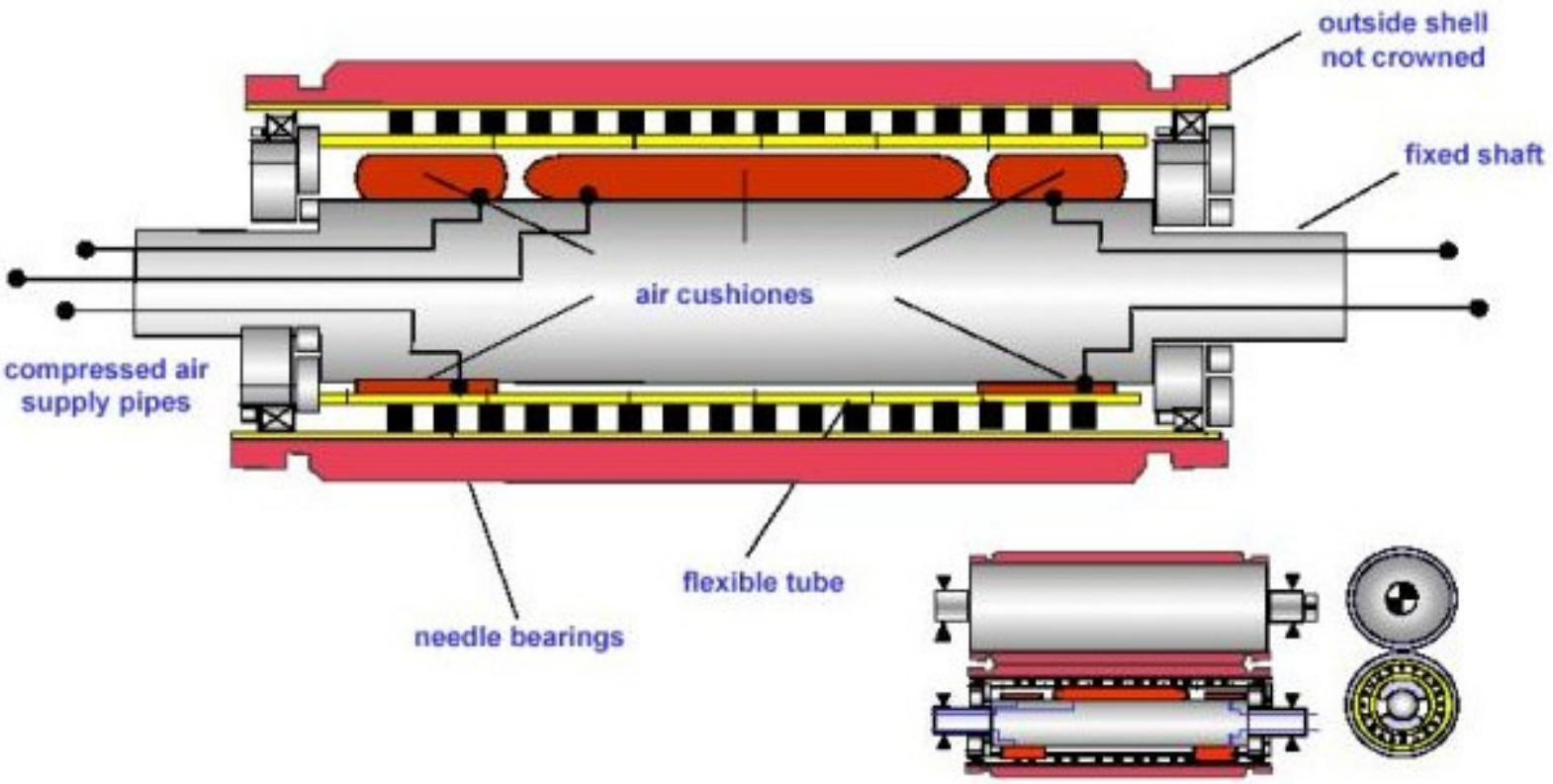
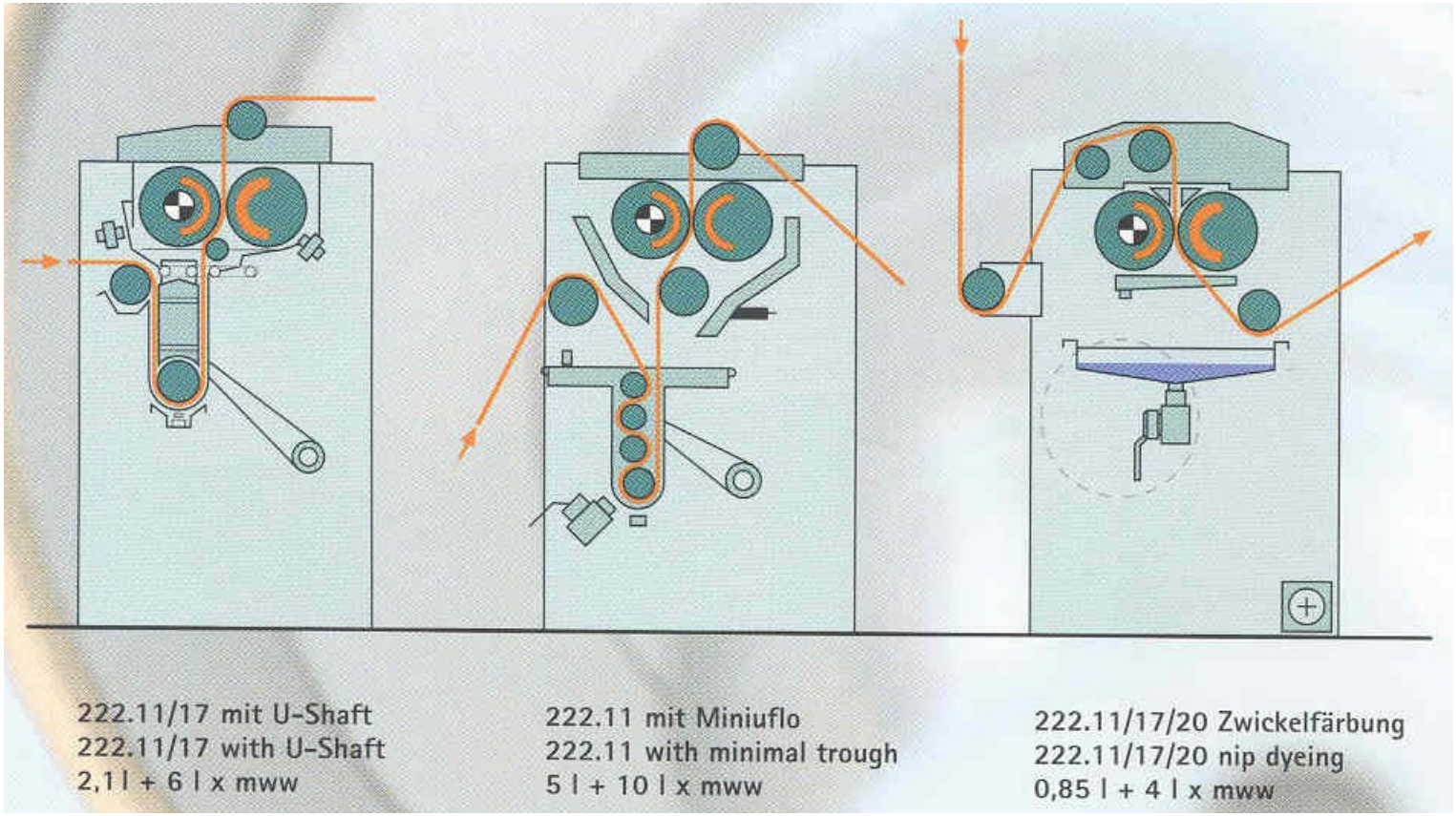
BICOFLEX® roll



Trough content

- The volume in the pad trough should be relatively small (20 – 50 litres) and automatically controlled at a constant level throughout the run
- Pad bath level variations result in a shade differences caused by variations in immersion time & pick up
- The pad liquor turnover time should be as fast as possible (less than 5 minutes).
- The pad liquor should be distributed uniformly across the full width of the padder through a perforated tube

Economiser troughs



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Pick up, immersion time, speed

Pick up

Must be uniform across the width and consistent from batch to batch (60 – 80% for CEL, 45 – 55% for PES/CEL)

Pick-up depends upon:

- ➔ **Pad pressure and speed (fabric penetration, wetting out)**
- ➔ **Dye level in the trough (dip to nip time)**
- ➔ **Dyebath chemicals (penetration accelerant)**
- ➔ **Fabric (fibre and construction)**

Immersion time

Should be 1 – 2 s for cotton and 2 – 4 s for viscose and tencel.

Speed

Must be constant throughout the run - No stoppages

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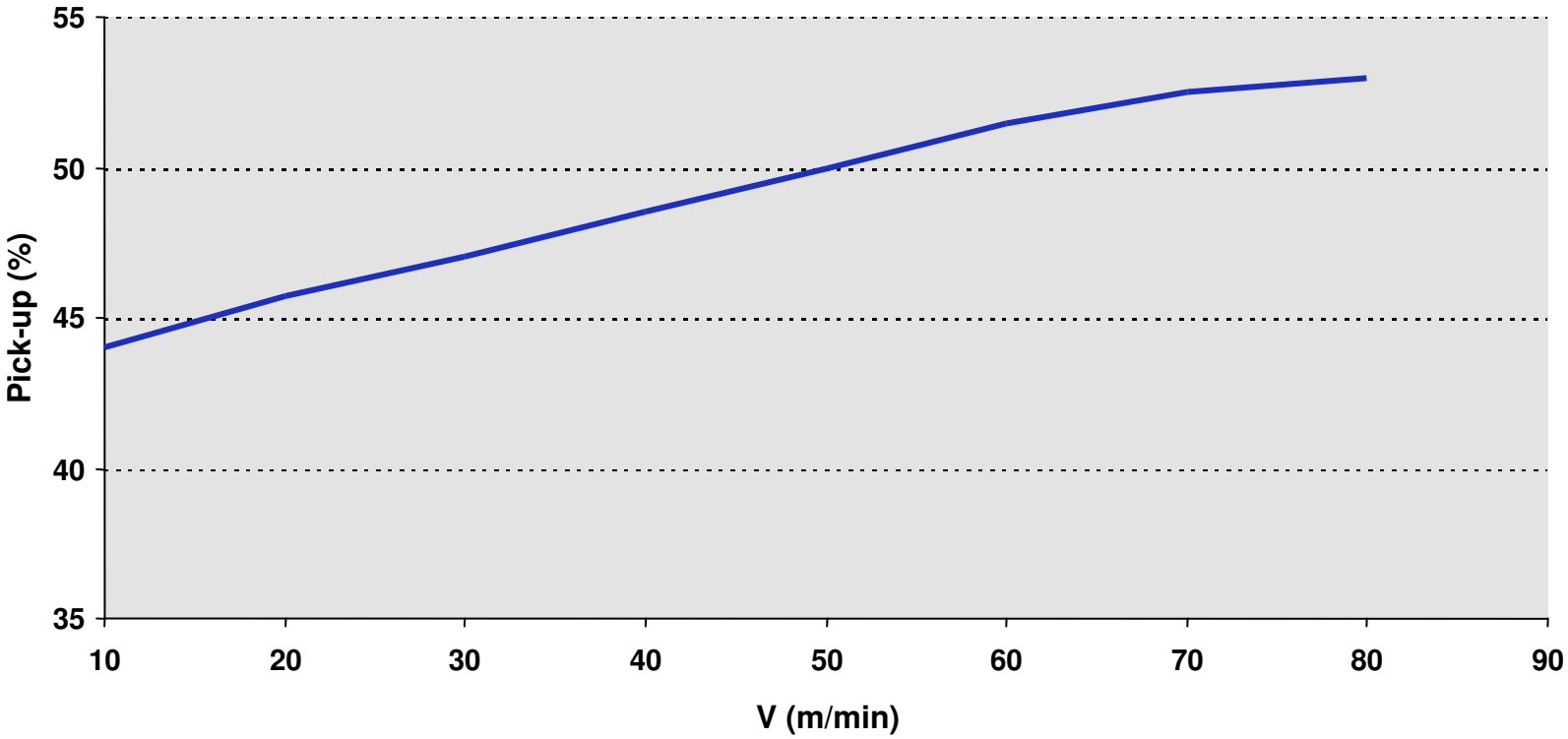
Influence of padding speed on pick-up



Fabric: PES/CO 67:33, 200 g/m², 151.5 meters wide, P = 40/40/40 daN/cm

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Padding temperature

Pad bath temperature is critical and must be within the specification.

Pad bath temperature influences the behaviour of the dyes:

- **Substantivity (reactive dyes)**
- **Bath stability (hydrolysis of reactive dyes)**
- **Dye fixation rate**
- **Dispersion stability (vat and disperse dyes)**

Pad bath temperature is influenced by:

- **Friction on the pad rolls**
- **Dissolving/dispersing the dyes at too high temperature**
- **Local working conditions (hot climates)**
- **Too high fabric temperature**

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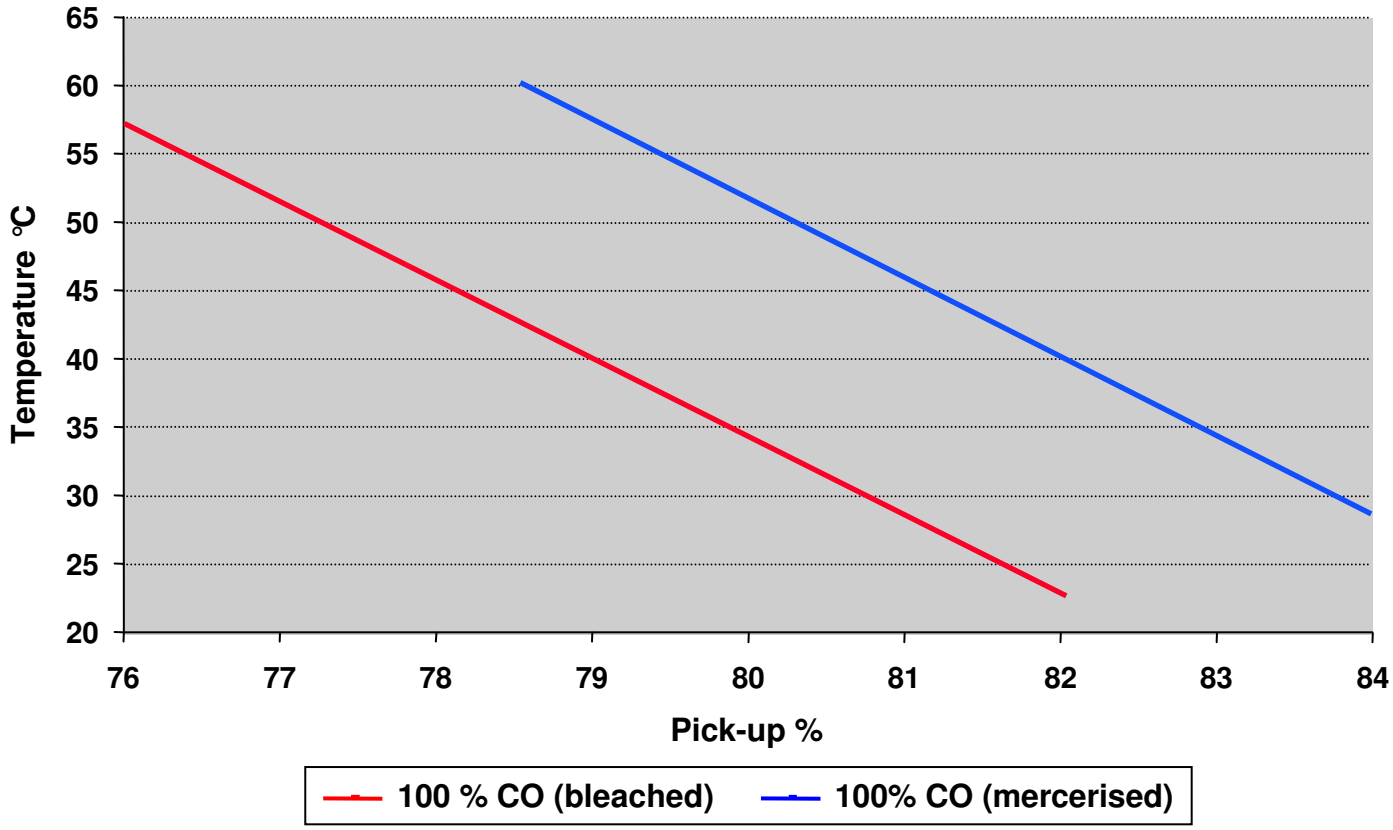
Influence of padding temperature on pick-up



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Drying

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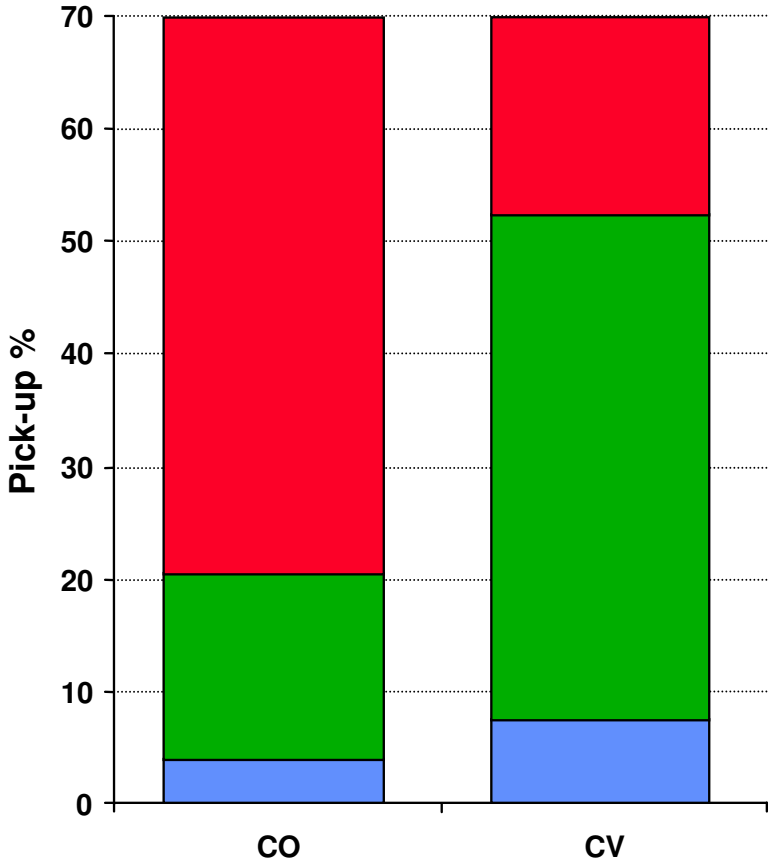
Distribution of the liquor on the fibre after padding



Swelling or absorption water fixed by H bonds:
~ 4 - 6%. Fibres moisture regain.
Very difficult to remove (over drying)

Swelling or absorption water on the amorphous regions of the fibre:
~ 15%. Difficult to remove (drying)

Surface and capillary water:

- **~ 25% retained on the fabric surface by cohesive forces. Removable by mechanical means (IR drying)**
- **~ 25% retained by adhesive forces between the individual fibres (capillary water).**

Can be partly removed by mechanical means.

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Migration

- During the intermediate drying phase, dye molecules tend to diffuse with water molecules as they migrate from the wetter towards the drier parts of the fabric

- High affinity dyes migrate slower but unfortunately lead to poor penetration, tailing and washing-off problems !!

- Dye molecules continue to migrate as long as water molecules diffuse from the surface of the fabric. Migration stops when the moisture content of the fabric has dropped below 30%

Consequences of too high migration

- Horizontal migration on the fabric surface is responsible for unlevel dyeing & side-centre shade variation
- Vertical migration through the fabric is responsible for frosting & face-back shade variation

How to control dye migration

- ✓ Lower pick-up
- ✓ Skying between padding and drying
- ✓ Addition of electrolyte to increase dye affinity (but risk of tailing)
- ✓ Infra-red pre-drying (most important)
- ✓ Well balanced air flow in the dryer
- ✓ Use of a migration inhibitor
- ✓ Better dye selection

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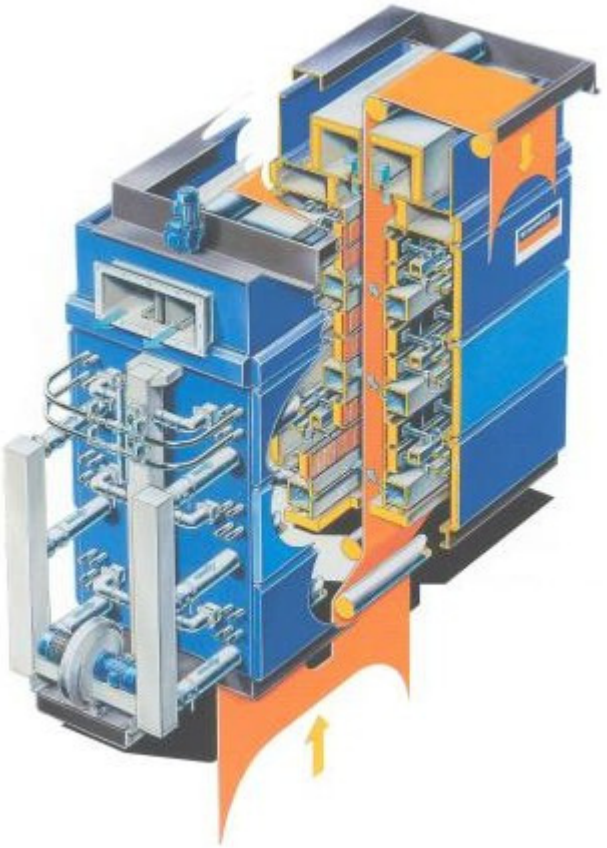
Infrared pre-drying

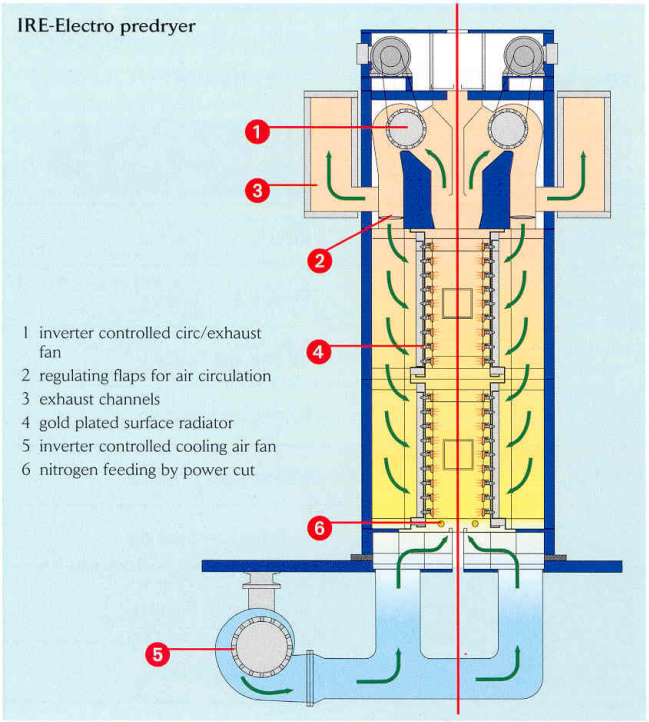
Removal of as much as 50% of the water from the padded fabric in the absence of strong air currents and fabric to metal contact, which accelerate dye migration.

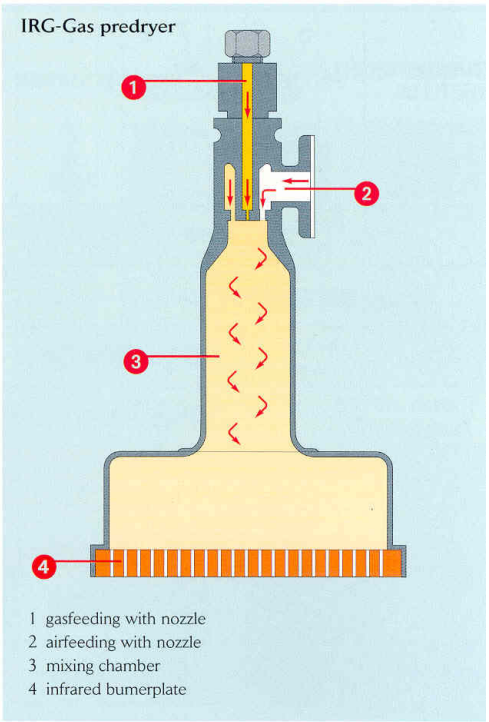
Requirements of an infrared pre-drier

- Gas or electrically heated
- Equilibrium setting up time
- Temperature/capacity adjusted depending upon weight of fabric
- Moisture content of fabric after pre-drying
- Setting of protective shields during downtime
- Cleaning of guide rollers

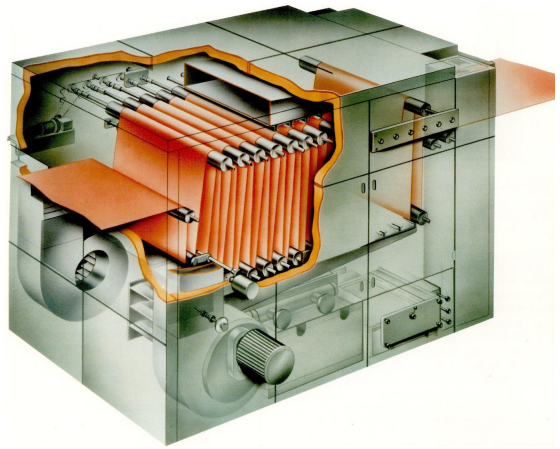
THERMRAY - Infrared Pre-drier







Hotflue Driers



- Equilibrium setting up time
- Uniform air distribution
- Temperature control
- Uniform fabric tension to prevent creasing
- Graduated temperature between the hot flue chambers
- Drying time – no over drying
- Cooling down of fabric after drying

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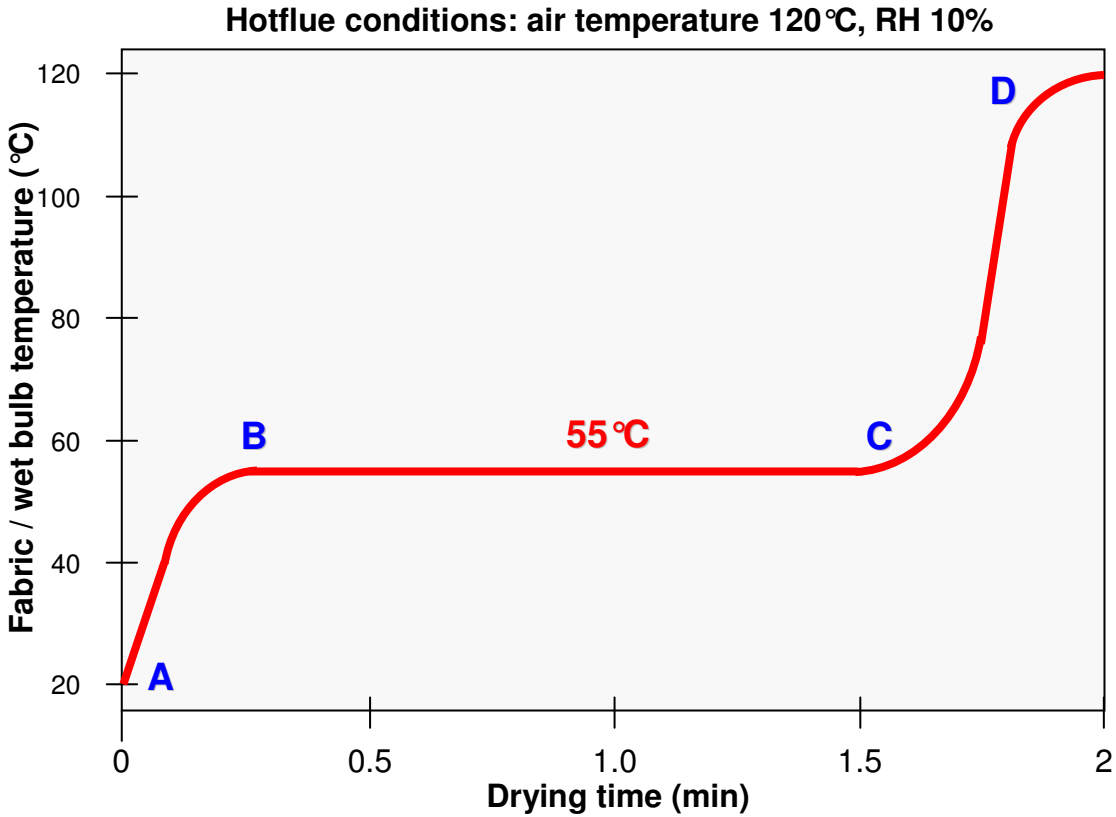
Drying Profile



Phase 1

The fabric temperature increases rapidly before reaching an equilibrium (B - C) which corresponds to the wet bulb temperature. In a hot flue at 120℃/10% RH, the fabric (or wet bulb) temperature is 55℃ and stays constant as long as free water diffuses from the fabric surface.

Phase 2

At the beginning of the second phase (C - D) the moisture content of the fabric is ~20-25%. The fabric temperature rises, and the moisture content reduces, to that of the hot air.

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THERMEX - Hotflue Thermosol

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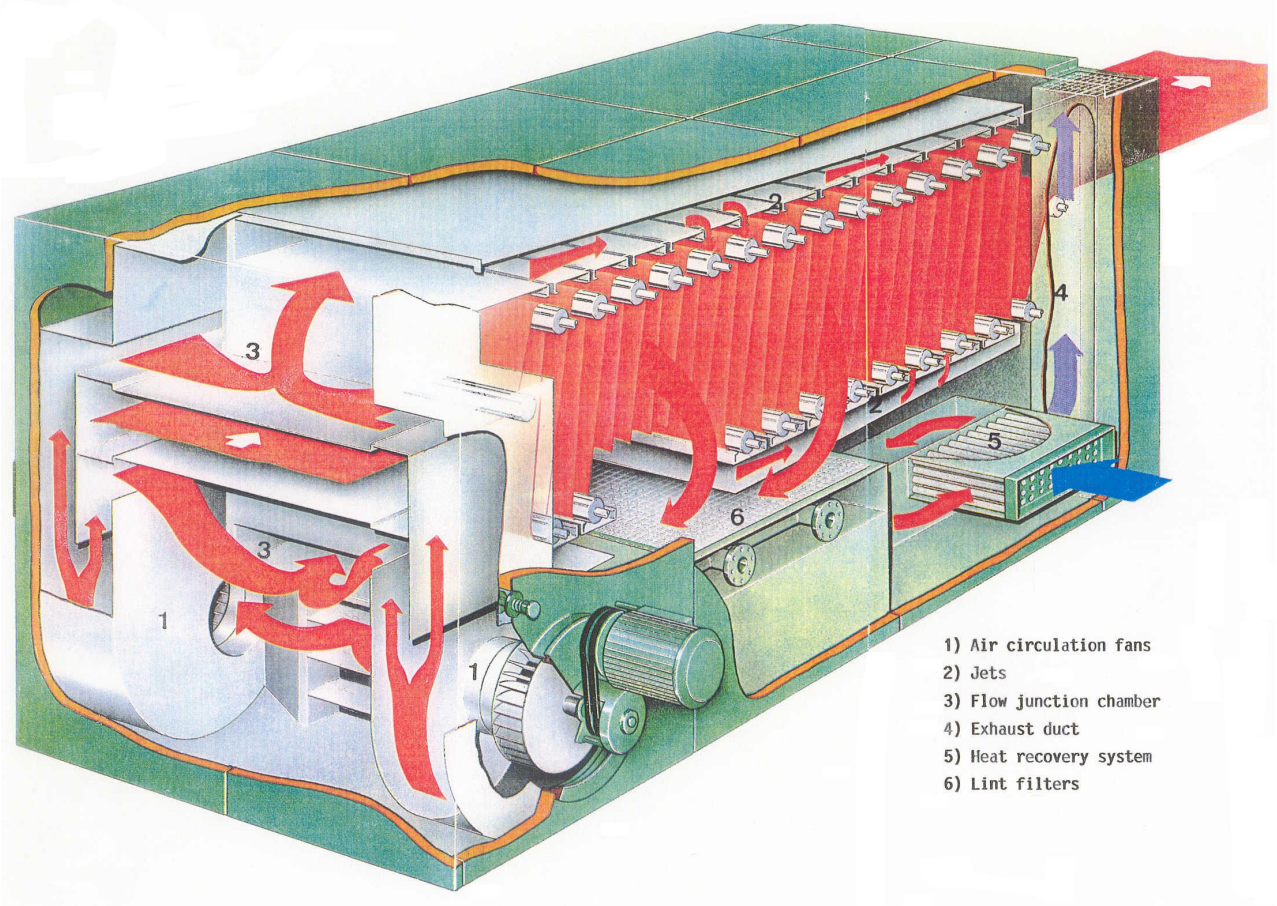

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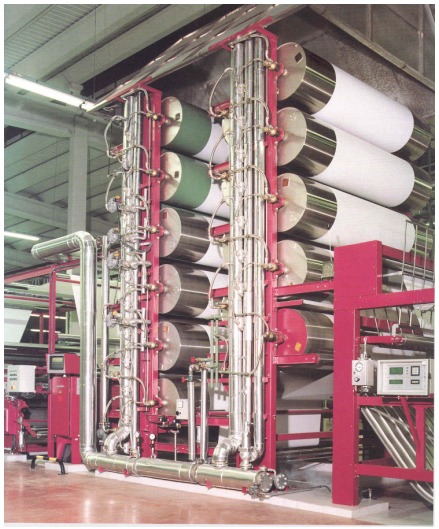
Cylinder driers



- Cylinders must be properly aligned, well balanced and clean
- Graduated temperature control: Prevents fabric over drying
- Sufficient steam pressure and supply: Prevent condensation in the cylinders
- Cylinders of smaller diameter, are used for pre-drying, compared to final drying, to control migration. Shorter contact distance
- Fabric cooling after drying

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Steaming

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Steam Fixation: Process requirements

- **Equilibrium setting up time**
- **Sufficient steam pressure and supply**
- **An air free atmosphere of saturated steam**
- **Prevention of condensation drops** (heating of steamer entrance & roof)
- **Measurement of wet & dry bulb temperatures**
- **Fabric cooling before padding**
- **Chemical pad recipe and pick up**
- **Fabric tension and steaming time**
- **Water seal**

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Air free atmosphere

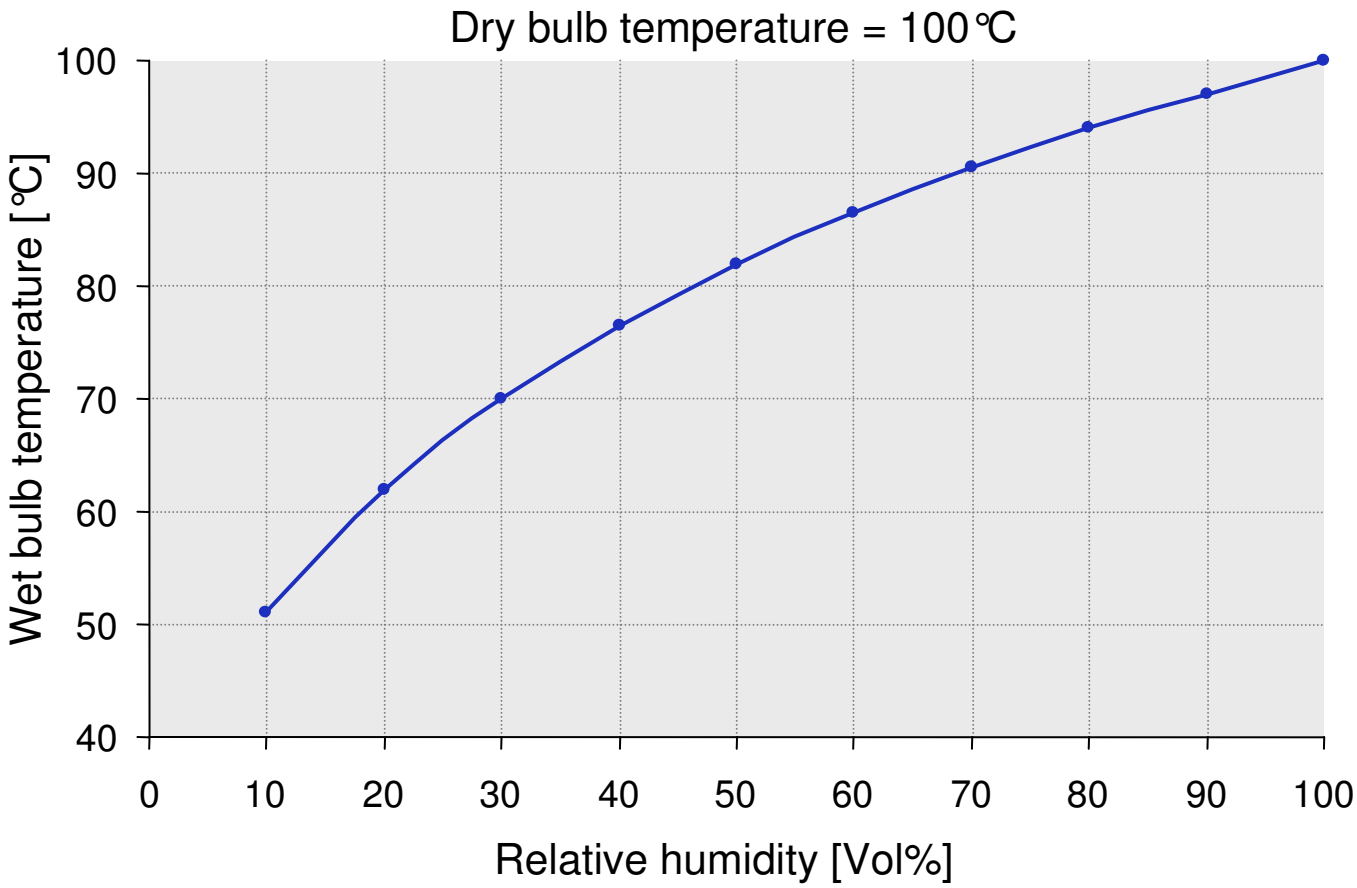
The fixation of reactive dyes and the reduction of vat dyes is carried out in a steamer with an air free atmosphere of saturated steam.

The dry bulb temperature, is the temperature of the atmosphere inside the steamer. It is determined by the temperature of the steam. At high altitude the temperature of the steam decreases.
t °C = 100 – 3.2 x h (h = altitude in km)

The wet bulb temperature, is the temperature reached by the fabric inside the steamer. This temperature is effectively the fixation temperature and depends not only on the temperature of the steam, but also the moisture content.

Fabric temperature as a function of moisture content during steaming

(at normal atmospheric pressure 1 bar / 0.9862 atmospheres)



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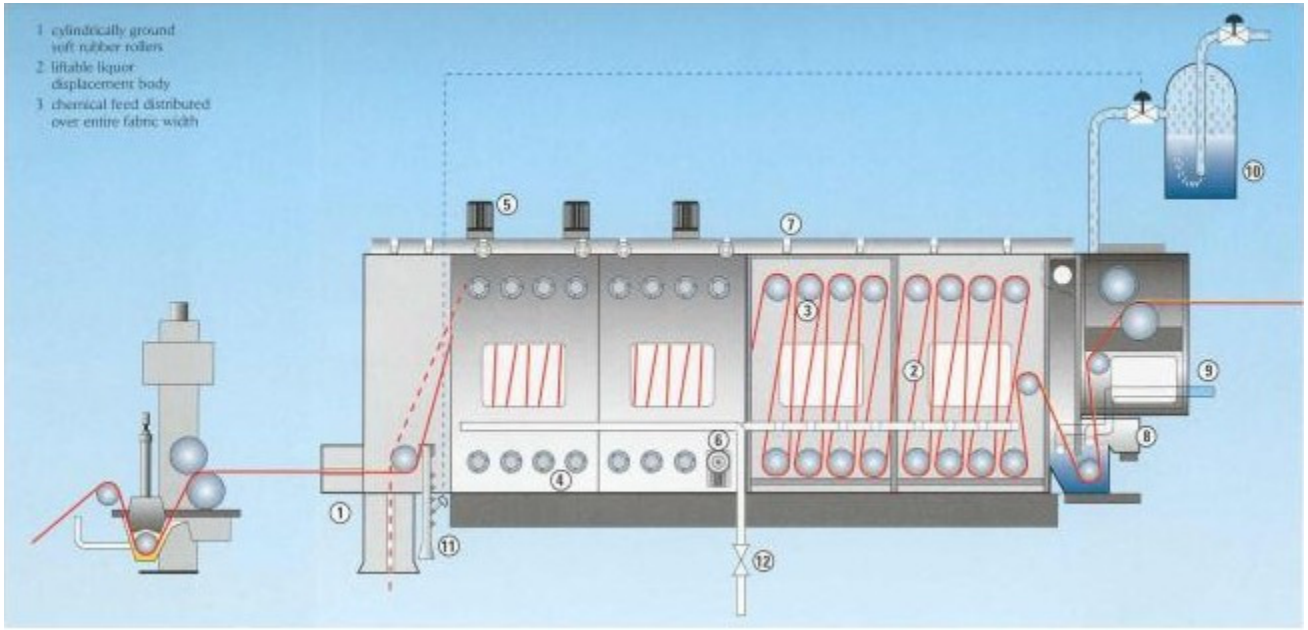
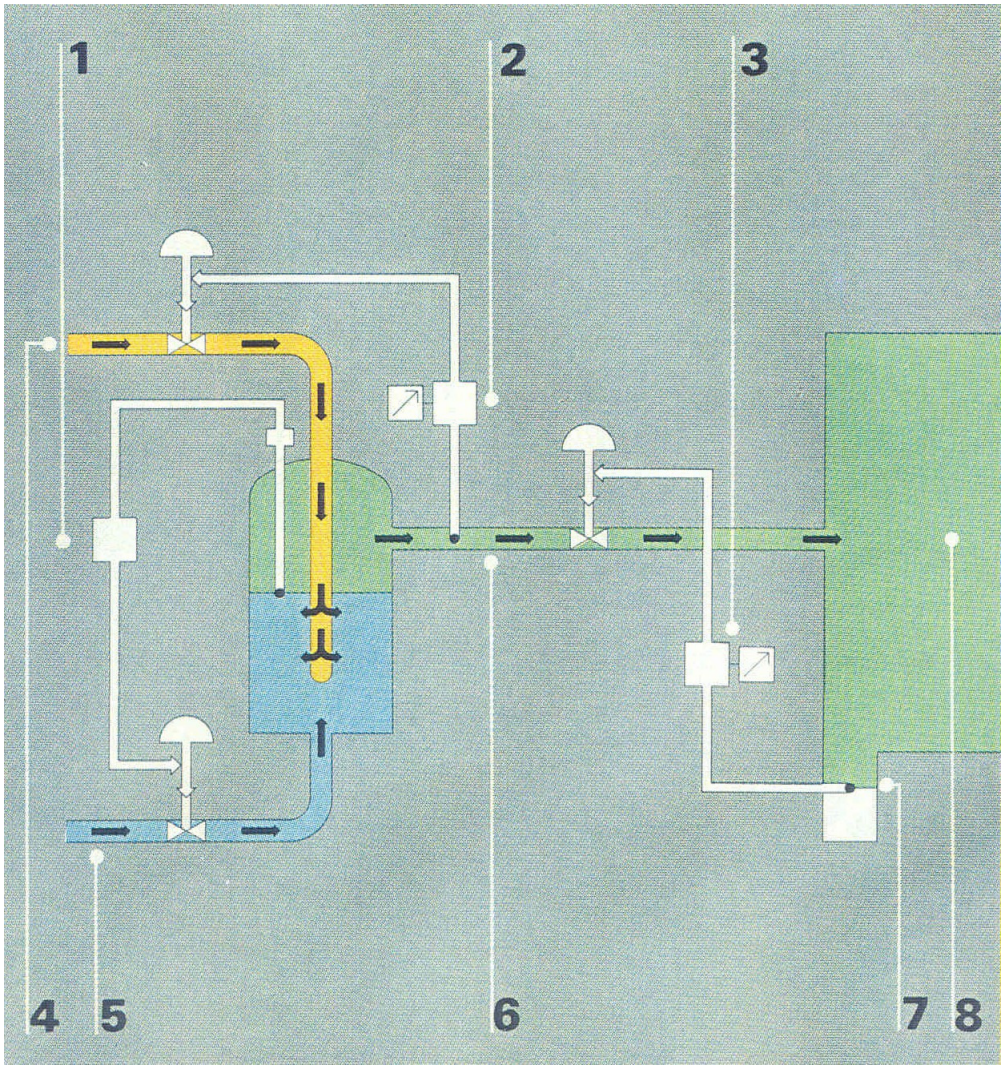
REACTA - Dyeing Steamer



1. Horizontal or vertical fabric entry with heated lips and exhaust fan for excess steam.
2. Section with 25 metre fabric content.
3. Large roller diameter (193 mm) for creaseless fabric run.
4. Lifetime lubricated bearings.
5. Top rollers individually driven by AC-motors.
6. Load cell to measure fabric tension for drive control.
7. Roof heating.
8. Water seal with small liquor content and uniform liquor distribution.
9. Temperature or volume controlled fresh water flow to the water seal.
10. Steam conditioning unit.
11. Probe to measure the steam condition (below steamer bottom level).
12. Automatic cleaning system (optional).

Automatic steam conditioning and control station



1. Automatic control of soft water level
2. Automatic control of steam quality
3. Automatic control of steam quantity based on consumption
4. Steam supply from works network
5. Soft water
6. Saturated steam
7. Steam level
8. Steamer:
   Air free - constant steam conditions

Washing Off

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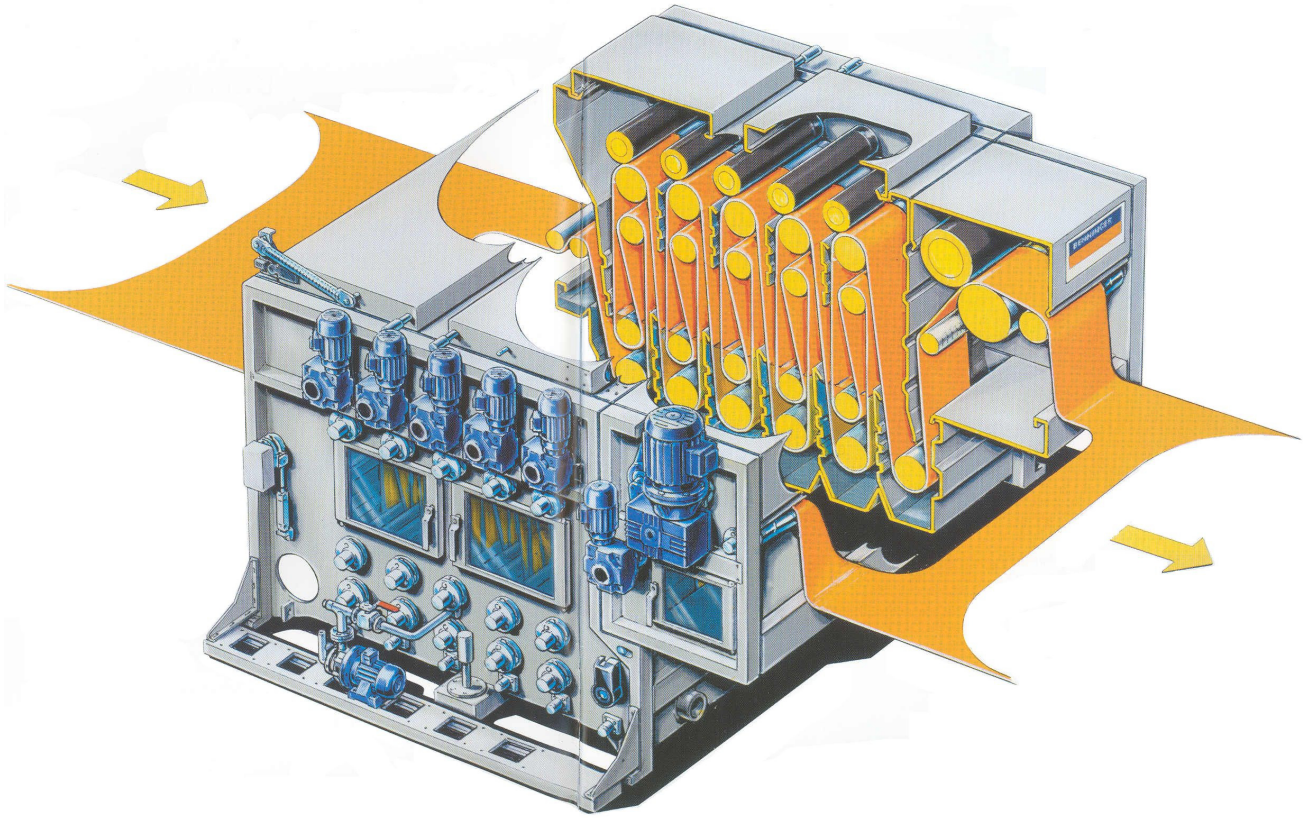
Washing Off

Machine requirements

- Usually 6 - 8 boxes
- Double threading, squeezing rollers inside washing box
- Counter flow and overflow facilities
- Temperature control in each box
- Intermediate nip rollers, with spray pipes, between boxes
- Enough steam capacity to quickly heat up the incoming water
- Facilities for dispensing chemicals
- Efficient squeezing, after the last wash box, before drying

EXTRACTA - Open-width washing machine



High washing efficiency with low water usage

EXTRACTA - Open-width washing machine