Introduction to process and properties of tissue paper

TECNICELPA

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Enrico Galli self-presentation

- I was born in Viareggio (Lucca county or "the so called tissue valley") Tuscany - Italy
- Graduated in Chemical Engineering at University of Pisa in 1979
- Process and project engineer and then technical manager in oil industry (oil refineries and spent lube oil re-refining) in GULF, API, AGIP in Italy
- Technical manager in chemical and consumer products company (soap, detergents, derivate from fatty acids, sanitary gloves, tissue paper) in Italy.
- Since 1984 in paper and tissue business:
  - Italy: Tissue (PM, PBD, CON), Newspaper (PM), Cardboard paper (PM, MM)
  - Estónia: Tissue (PM, CEO)
  - France: Tissue (PM)
  - Hungary: Tissue (CON)
  - Nigéria: Tissue (CON)
  - Romania: Tissue (PM, PBM, MM, CON), Writing paper (PBM)
  - Rússia: Tissue (PM)
  - Spain: Tissue (PBM)
  - UK: Tissue (PBM)
- Cooperation with following main European Tissue Companies: Annunziata (now WEPA – Italy), GP (now Lucart – Italy), Horizon Tissue (Estonia), Imbalpaper (now Sofidel – Italy), Kartogroup (now WEPA – Italy, France, Spain), Montebianco (Romania), Pehartec (Romania), Perini (now Sofidel – Romania, UK), Siktyvkar Tissue Group (Russia), Vaida Papir (Hungary)… **and now proudly NAVIGATOR in Portugal!**
- I have been supporting Sales and Marketing Teams for strategic planning as well as for products development in Baltic Countries, BENELUX, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Norway, Poland, Romania, Russia, Spain, Sweden, UK.
- Since 1998 I have been teaching "Paper plants and tissue production and converting" at the University of Pisa (Italy).
- Since 2015 I have been giving aula about Tissue Technology at the University of Coimbra (Portugal)

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“tissue”: what, where, how

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What is "*tissue*"?

In paper business the world "*tissue*" includes all paper products used for hygienic and sanitary purposes both at home ("consumer" or At Home – AtH – products) and/or in public places ("catering" or HOtel REstaurants and CAfé – HORECA – or Away From Home – AFH – products): "*tissue*" is therefore toilet paper and kitchen towels but also handkerchiefs, napkins, industrial rolls, facial tissues, medical sheets, etcetera).







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What's inside the "pack"?

We can assume that inside a toilet paper pack we should find some toilet paper rolls, but the different market actors' selling strategies as well as the different consumers' attitudes and needs require different tissue products quality and packaging:

- **Entry level or "first price" products: these products match only the basic required performances, they are very often low quality raw materials based and sold in minimalist packaging (standard packs with few color images). They are present in hard discounts while in supermarkets they are identified as "first or best price"; the same ones can be found on hawker benches, local markets, suburban bazaars.**
- **Brand products: branded products lines by big local and multinational companies and - in this case - present on different national markets. These lines are internally developed and very often supported by dedicated advertising campaigns. The best techniques both for paper production and converting/packaging available in each company are used to design products with some gaps Vs. other ones in the market. These products are "necessary" present in most selling points due to consumers' request.**
- **"private label": products sold using the (sometime more than one for quality and price differentiation) retailer brand and produced by third companies. Big retailer chains are requiring higher and higher products quality comparable with the best ones in the market to use the consumer loyalty to the retailer brand and a lower selling price as competition advantages Vs. branded products.**

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O mercado mondial do papel tissue

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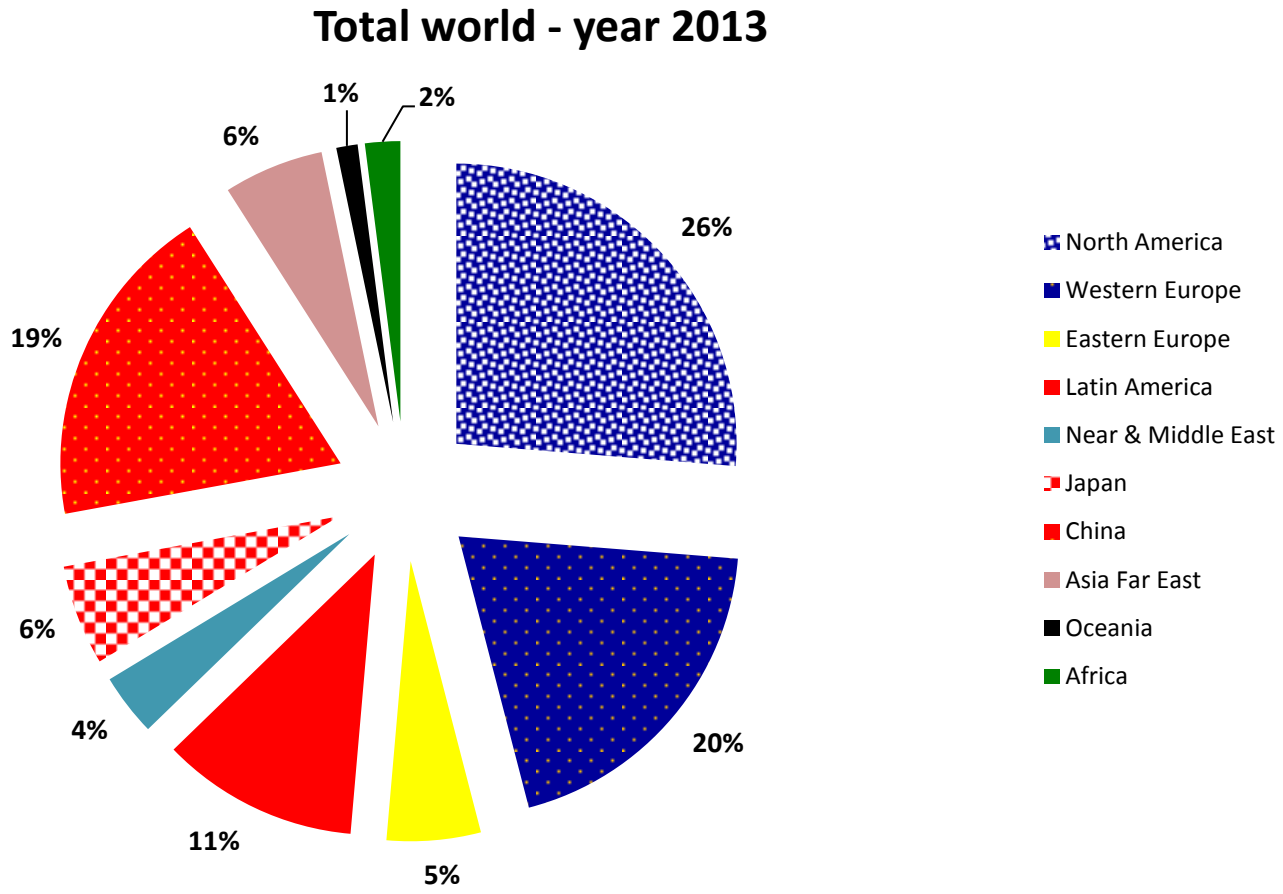
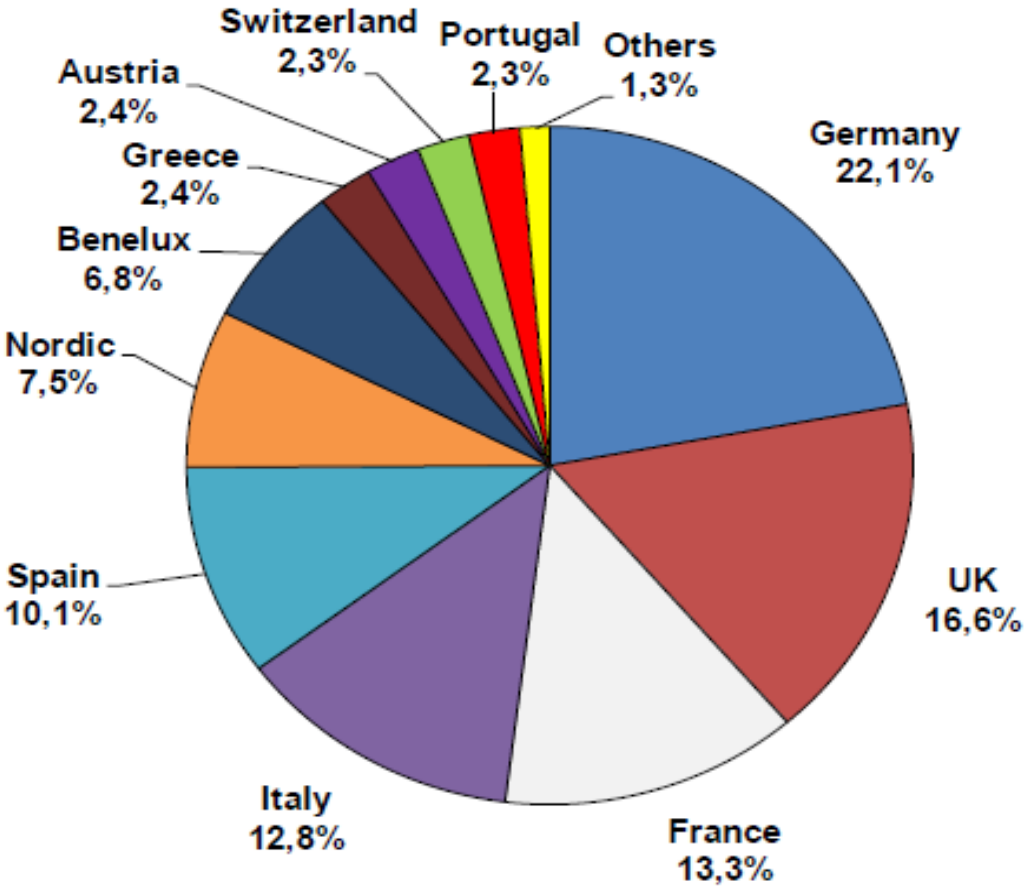
World consumption distribution



Total consumption: 32,5 MMtons (year 2013)
that represents about € 50 billion

source: RISI, 2014

Western Europe tissue consumption by main country



Total Consumption: 6.4 Million Tonnes (2014p)

Main markets: Germany, UK, France and Italy

Peninsula Iberica (Spain & Portugal) market size is about the same as Italy or France

source: RISI, 2015

Consumer products characterization and testing

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The consumer tissue products

We can include in consumer category all the tissue products sold to the final consumer for at home (and personal) use:

- Rolls
  - **Toilet paper**
  - **Kitchen rolls (towels)**
  - Special wipers
- Folded products:
  - **Napkins**
  - Towels in sheets
  - Handkerchiefs
  - Facial box tissues
  - Wet and moistured tissues

grupo Portucel Soporcel

Toilet paper

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Toilet paper rolls are identified through following characteristics:

- Base paper:
  - quality: virgin pulp, de-inked pulp, mixed
  - basis weight: normally from 15 to 17 g/m^2
  - White or colored ◎
- Roll (elementary unit)
  - Number of plies: normally 2, 3 and 4 (but also 5 in some markets)
  - Ply bonding:
    - Lamination: plies are glued together (only for embossed products)
    - Mechanically: edge embossing
  - Embossing type and pattern: the surface sculpture of the paper
  - Decoration:
    - Colored glue
    - Printing
  - Others: perfume, balsam, etcetera
  - Roll height: normally from 90 to 100 mm

Toilet paper (continued)

- Roll diameter: normally from 100 and 120 mm as a function of the roll paper length and embossing type
- Number of services/sheets
- Service length: normally from 122 and 138 mm
- Core diameter: normally from 38 to 50 mm ◎

- Pack (Consumer Unit):
  - Type: horizontal or vertical
  - Number of rolls per pack
  - Packing material: normally multicolor printed PE or PP
  - Others: handle, easy opening, squeezed rolls

- Bundle (Selling/Commercial Unit)
  - Number of packs per bundle
  - Bundling material: normally plain PE

- Pallet (Logistic Unit)
  - Type of pallet: normally EURO (80x120 cm)
  - Display pallet: packs without bundle are directly displayed on the pallet for direct picking by consumer

Toilet paper: consumers' expectations

Most important technical characteristics and performances required for consumer toilet paper are the following:

- Softness:
  - sensorial characteristic resulting from bulk (~ thickness), surface smoothness (~ hand-feel) and reduced rigidity (sometimes called "clothness" to indicated that the paper looks like a "rag");
  - Bulk and smoothness can be measured both on base paper and finished product, but the only reliable way to evaluate the finished product softness is a "comparative panel test";
- Dry strength:
  - Represents an indication of the product adequacy to its primary use;
  - It can be measured (MD and CD) both on base paper and finished product and practical/standard values exist;
- Wet strength:
  - Is related to the capacity of the product to be easily dissolved to avoid any toilet blockage problem;
  - It can be evaluated both on base paper and finished product as max (~ 10%) acceptable percentage of the dry strength and/or the finished product "solubility" and flush-ability can be directly tested;
- Perforation efficacy:
  - Perforation must be strong enough to get the request number of sheets, but not too strong provoking the longitudinal crashing of the sheets;
  - It can be evaluated on finished product as ratio Vs. dry [MD and CD] strength.

Kitchen rolls

Kitchen rolls are identified through following characteristics:

- Base paper:
  - quality: virgin pulp, de-inked pulp, mixed
  - basis weight: normally from 18 to 22g/m^2
  - White or colored
- Roll (elementary unit)
  - Number of plies: normally 2 (but also 3 in some markets)
  - Ply bonding:
    - Lamination: plies are glued together (only for embossed products)
    - Mechanically: edge embossing (rare)
  - Embossing type and pattern: the surface sculpture of the paper
  - Decoration:
    - Colored glue
    - Printing
  - Roll height: normally from 225 to 260 mm (rare)

Kitchen rolls (continued)

- Roll diameter: normally from 100 and 120 mm as a function of the roll paper length and embossing type; actually “big” jumbo kitchen rolls up to 160 mm diameter are distributed in the consumer market
- Number of services/sheets
- Service length: normally from 210 and 240 mm
- Core diameter: normally from 38 to 50 mm

- Horizontal pack (Consumer Unit):
  - Number of rolls per pack
  - Packing material: normally multicolor printed PE or PP
  - Others: handle, easy opening
- Bundle (Selling/Commercial Unit)
  - Number of packs per bundle
  - Bundling material: normally plain PE
- Pallet (Logistic Unit)
  - Type of pallet: normally EURO (80x120 cm)
  - Display pallet: packs without bundle are directly displayed on the pallet for direct picking by consumer

Kitchen rolls: consumers' expectations

Most important technical characteristics and performances required for consumer kitchen rolls are:

- Absorbency:
  - Total (or practical) absorbency:
    - Represent the quantity [of water] that the paper absorb (and keep!) per unit of mass (weight);
    - It can be measured both on base paper and finished product and practical/standard values exist;
  - Absorption speed:
    - Represent the paper performances as "fast drinker"
    - It can be measured on base paper and practical/standard values for the base paper exist;
  - Finished product absorption performance:
    - Represent the "real" performance of one sheet of finished product in terms of absorbency and absorption speed;
    - It can be measured on finished product and practical/standard values exist on markets;
- Dry and wet strength:
  - Represent an indication of the product adequacy to its primary use;
  - They can be measured (MD and CD) both on base paper and finished product and practical/standard values exist on markets;
- Perforation efficacy:
  - Perforation must be strong enough to get the request number of sheets, but not too strong provoking the longitudinal crashing of the sheets;
  - It can be evaluated as ratio Vs. dry [MD and CD] strength of the finished product.

Napkins

Napkins are identified through following characteristics:

- Base paper:
  - quality: virgin pulp, de-inked pulp, mixed
  - basis weight: normally from 17 to 22 g/m^2
  - White or colored
- Napkin (elementary unit)
  - Number of plies: normally 1, 2 and 3
  - Ply bonding:
    - Lamination: plies are glued together (only for 2 and 3 ply full embossed napkins)
    - Mechanically: square embossing (only for 2 and 3 ply not embossed napkins)
  - Embossing type and pattern: the surface sculpture of the paper
    - All over embossing (only for 1 ply napkins)
    - Micro point-to-point embossing (for 2 and 3 ply napkins)
    - Square embossing (for 2 and 3 ply napkins)

Napkins (continued)

- Decoration:
  - Colored glue (rare)
  - Printing
- Dimension: normally 24x24 cm, 30x30 cm, 33x33 cm, 38x38 cm, 40x40 cm
- Folding: normally ¼, but also 1/8
- Horizontal pack (Consumer Unit):
  - Number of napkins per pack
  - Single (1 stack) or double (2 stacks)
  - Packing material: normally multicolor printed PE or PP
  - Others: easy opening ◎
- Bundle (Selling/Commercial Unit)
  - Number of packs per bundle
  - Bundling: normally cardboard box
- Pallet (logistic unit)
  - Type of pallet: normally EURO (80x120 cm) or demi-pallet (80x60 cm) but also quarter pallet (40x60 cm) for display boxes

Finished products (rolls) testing

- Elementary unit visual and dimensional analysis: roll diameter and height, sheets number and dimension, roll paper length (calculated), core diameter, roll weight, core weight, paper weight (calculated), number of ply, ply bonding system, embossing pattern description
- Softness: surface smoothness, panel test
- Physical tests:
  - Basis weight and single ply basis weight (calculated)
  - Tensile:
    - MD_{dry} and CD_{dry}
    - MD_{wet} and CD_{wet}
    - Ratios (calculated) MD_{dry}/CD_{dry}, MD_{wet}/CD_{wet}, MD_{wet}/MD_{dry}, CD_{wet}/CD_{dry}, $(MD_{dry} + CD_{dry})/2$, $(MD_{wet} + CD_{wet})/2$
  - Thickness and bulk (calculated)
  - "Solubility" and/or flushability
  - Absorption capacity: practical absorption, absorption speed, absorbency performance test
  - Brightness (when applicable)
  - Color and color stability (when applicable)
  - Ash content (only for DIP or mixed paper based products)

N.B. in red only for toilet paper – in blue only for kitchen rolls

Tissue paper production and [rolls] converting

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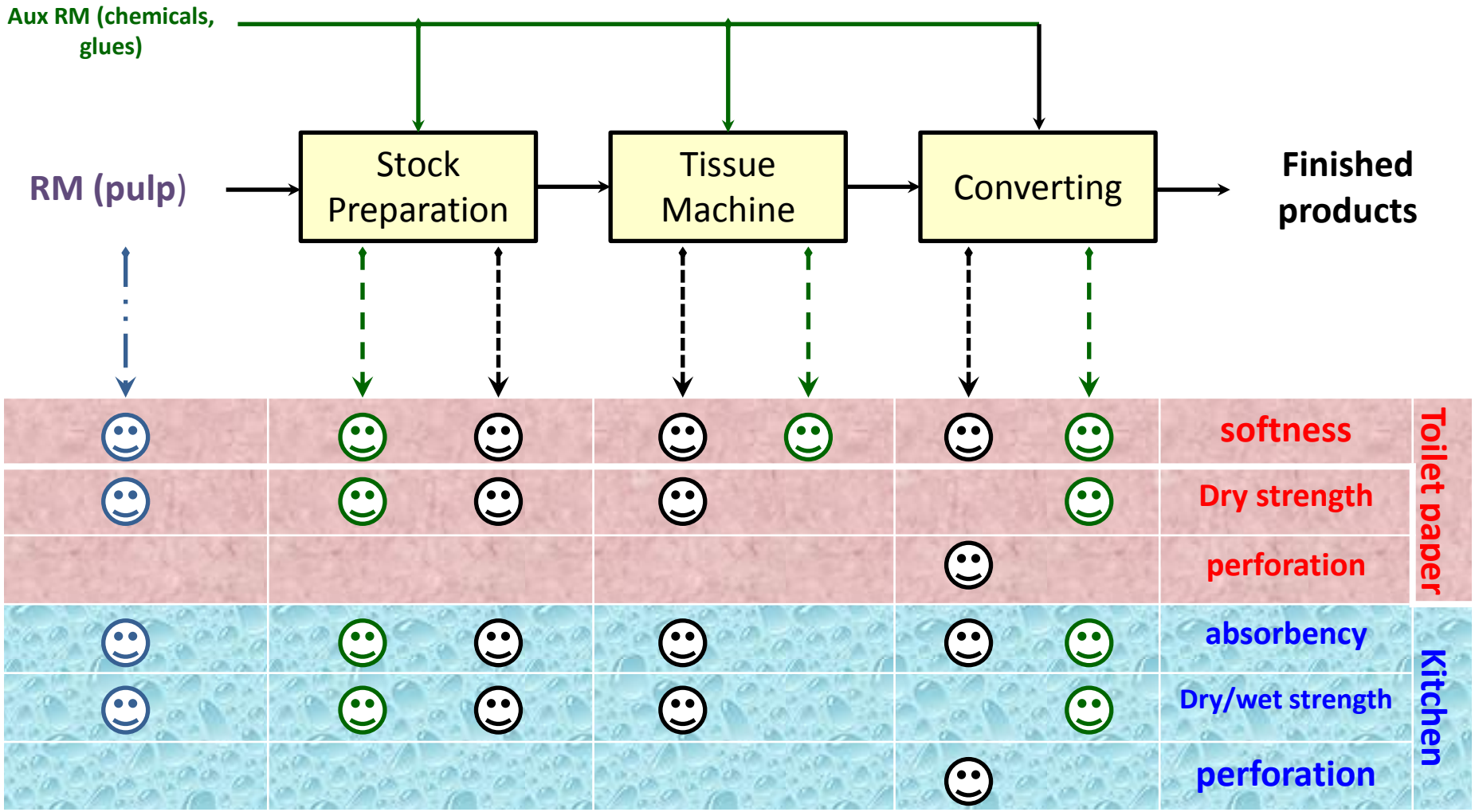
Rolls production and product quality



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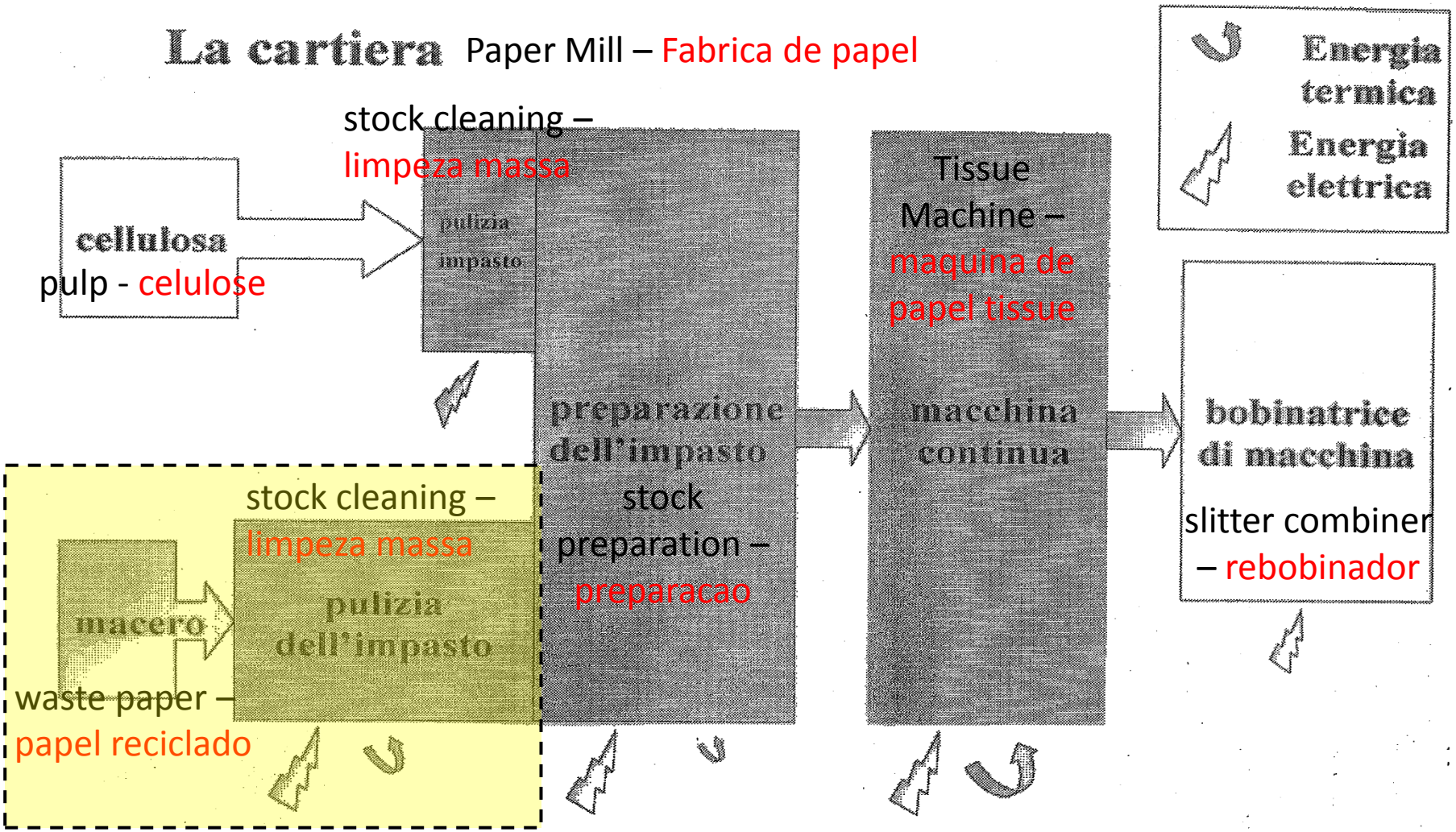
The Paper Mill



e. galli: Impianti di Cartiera I
A.A. 2000/2001

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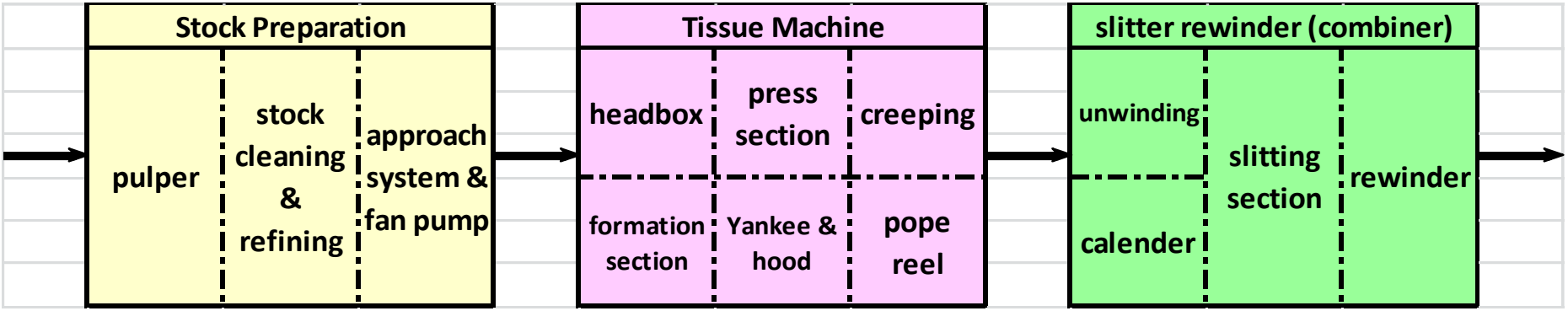
The Paper production process



Pulp bales are pulpered – Stock is cleaned and refined (SW & HW) and/or deflaked (HW) and then (approach system and fan pump) the fan pump fed to the Tissue Machine

Headbox "distributes" the stock on the full width of the forming section – Water is eliminated trough dewatering, mechanical pressing, evaporation – Creeping doctor tear out the paper web from the Yankee to the Pope Reel

Parent rolls produced at TM Pope Reel are [if necessary] calendered, combined and slitted to the required formats and rewind in JR

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Tissue paper production: Stock Preparation (SP)

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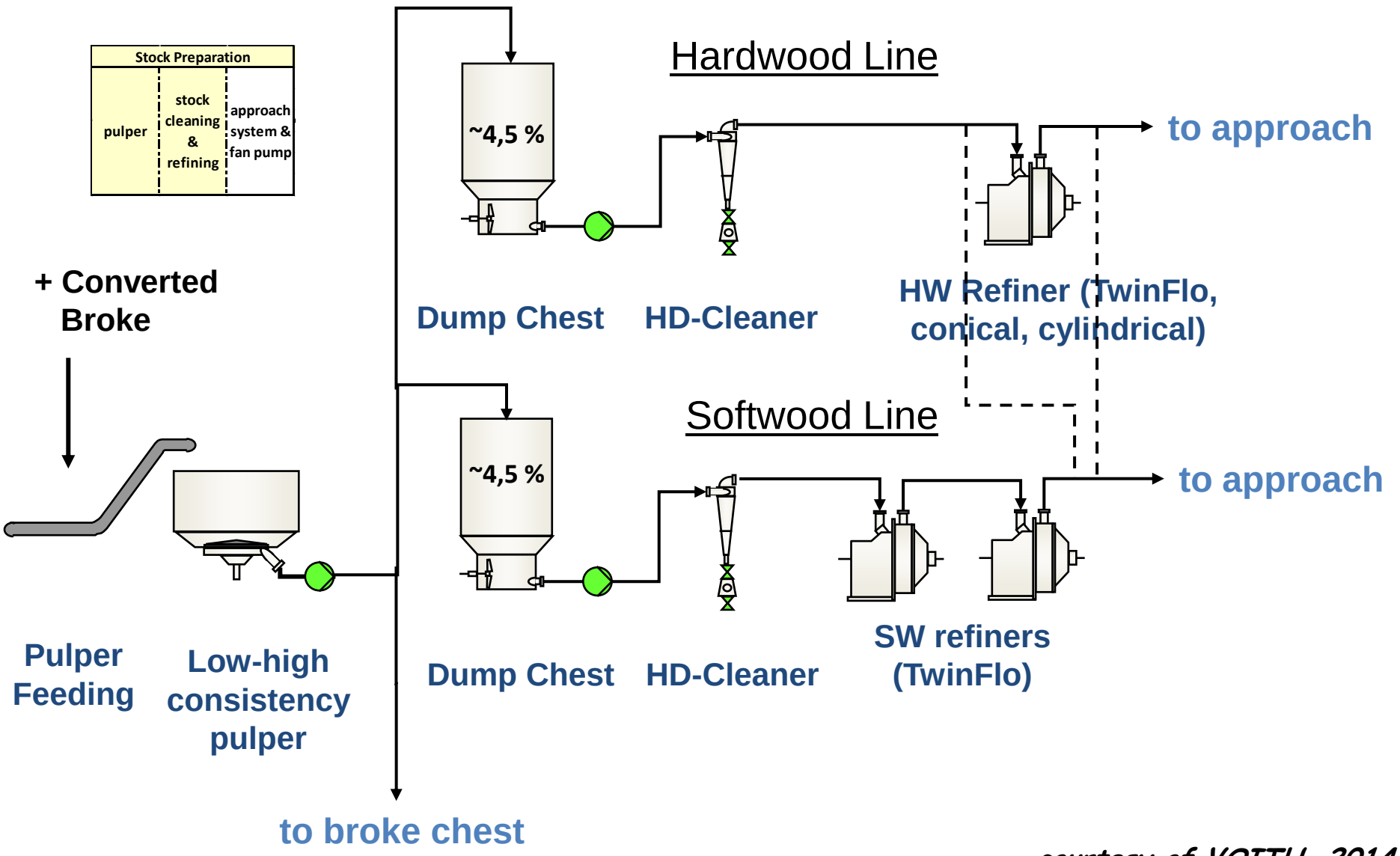
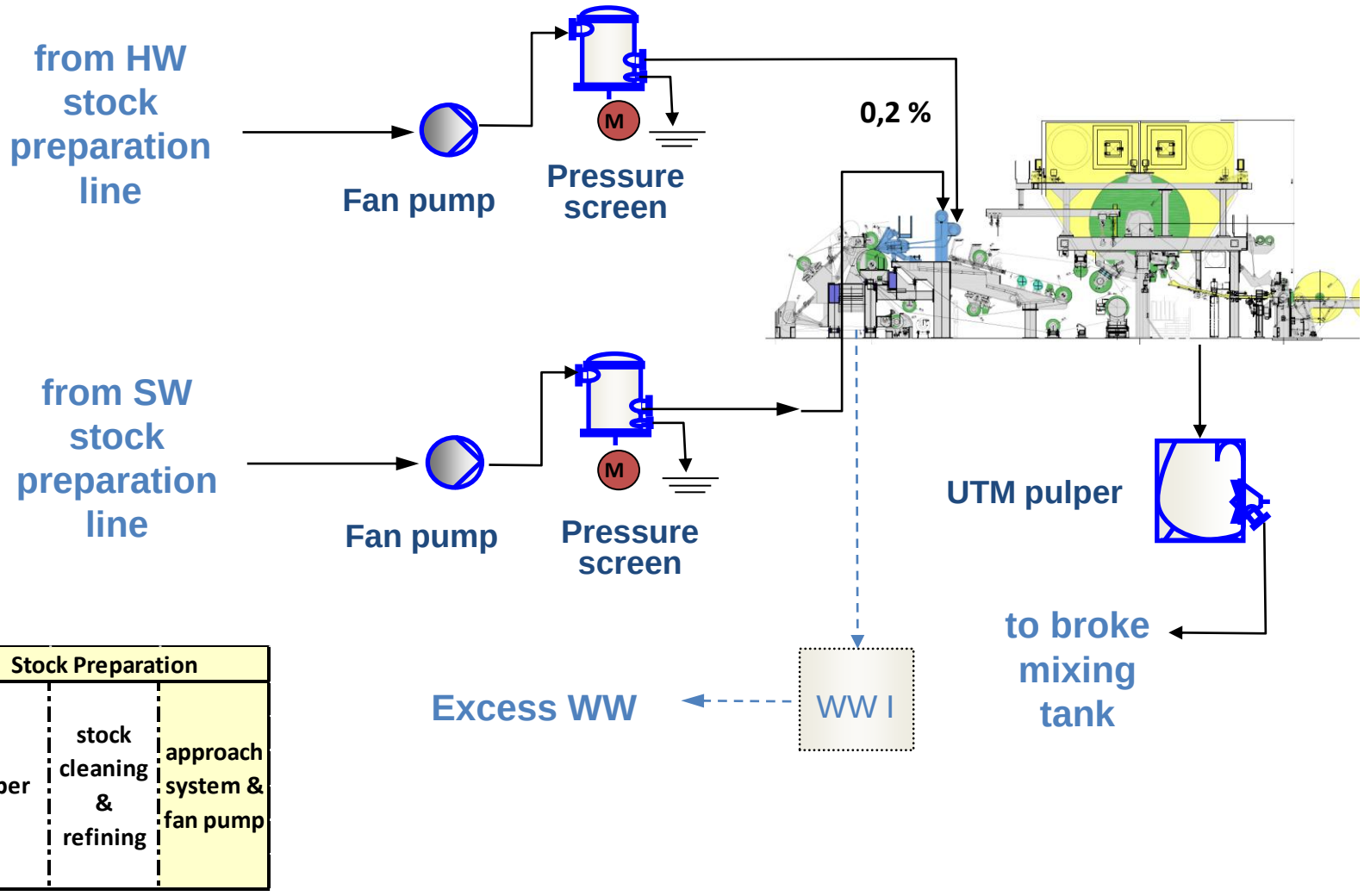
Virgin Pulp Stock Preparation



courtesy of VOITH, 2014

Approach flow and broke system



Stock Preparation		
pulper	stock cleaning & refining	approach system & fan pump

courtesy of VOITH, 2014

Tissue paper production: Tissue Machine (DCT)

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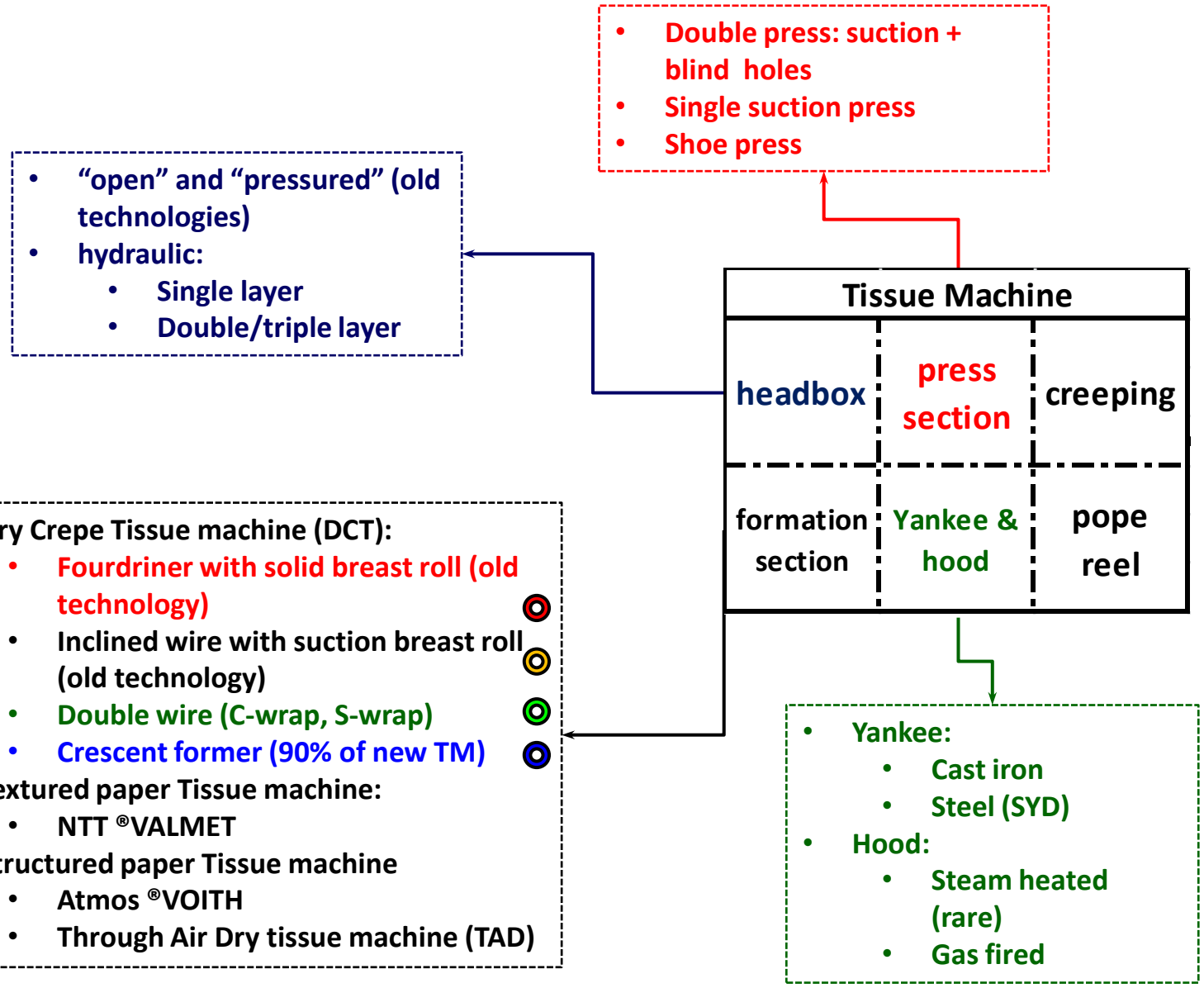
The Tissue Machine



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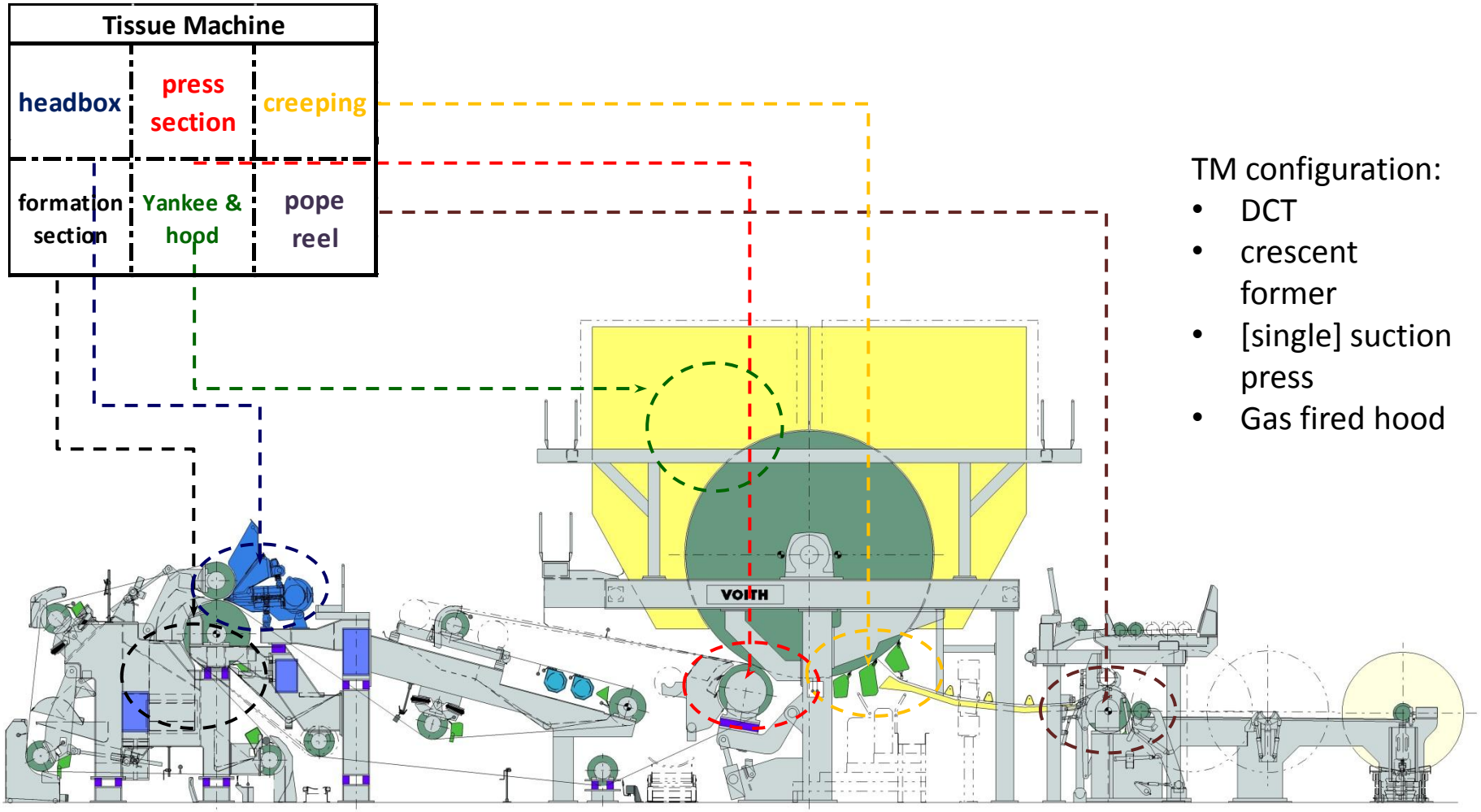
The Tissue Machine



TM configuration:

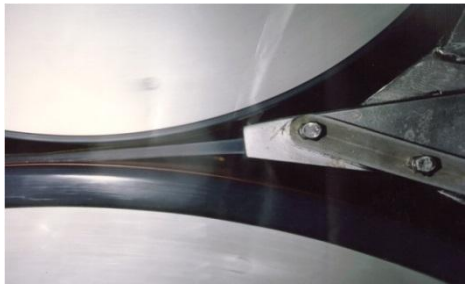
- DCT
- crescent former
- [single] suction press
- Gas fired hood

courtesy of VOITH, 2014

The Headbox

Tissue Machine		
headbox	**press section**	**creeping**
formation section	**Yankee & hood**	**pope reel**

The diluted stock is fed to the headbox through a distributor consisting of a manifold with variable section and different shapes; part of the stock could be recirculated for a better distribution control.



liquid pulp jet out from headbox

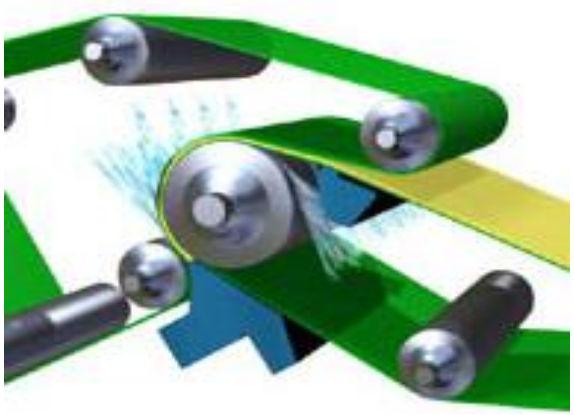
hydraulic headbox and distributor

The crescent former

Tissue Machine		
headbox	**press section**	**creeping**
formation section	**Yankee & hood**	**pope reel**

Crescent former:

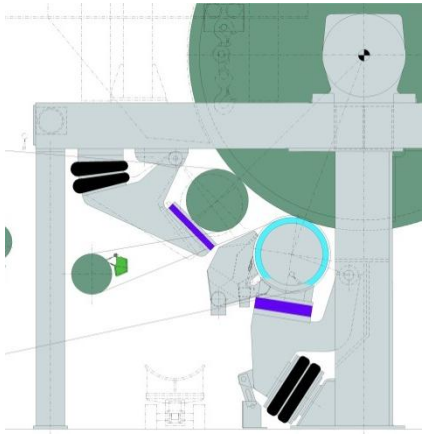
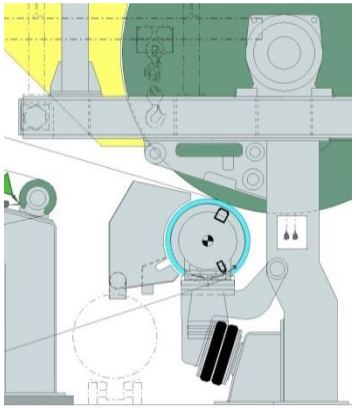
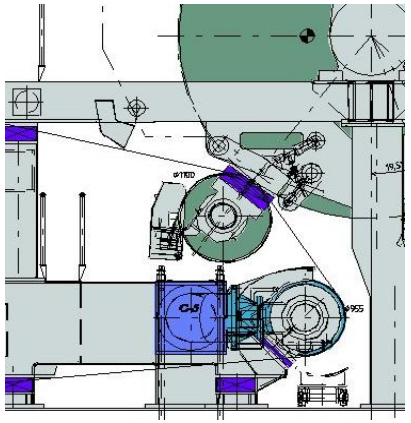
Forming between felt (yellow/green) and wire (green)



The press section

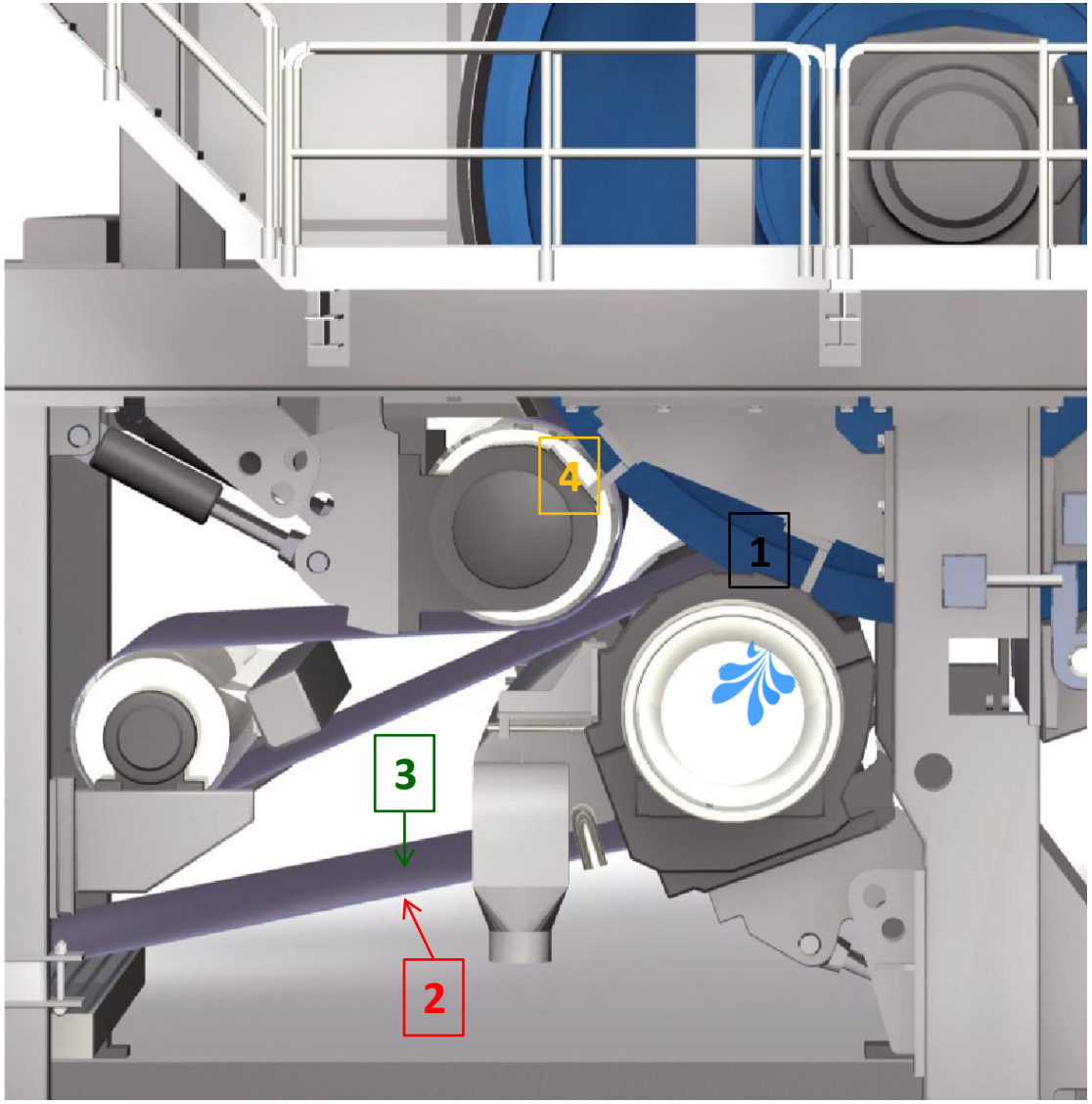
……..the TM press section evolution

Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

	Double press	SPR	Shoe press
			
Dry content	+	0	++
Production	+	0	++
Thermal energy demand	+	0	++
Bulk	-	0	+
Fiber savings	-	0	+

Source Metso Paper, 2014

Double-press DCT Machine



In the contact area (NIP) between the press and the Yankee (1) the paper web (2) - supported by the felt (3) - release the excess water to the felt itself: thanks to the vacuum applied water is transferred through the perforated surface (holes) inside the suction press and then eliminated.

Also in the blind holes press the excess water passes from paper web (2) to felt (3) in the NIP (4), but then is extracted from the felt thanks to the “pumping” action of the holes that keep the water under the NIP pressure and release it afterward: water is then eliminated due to the centrifugal force and press rubber elasticity.

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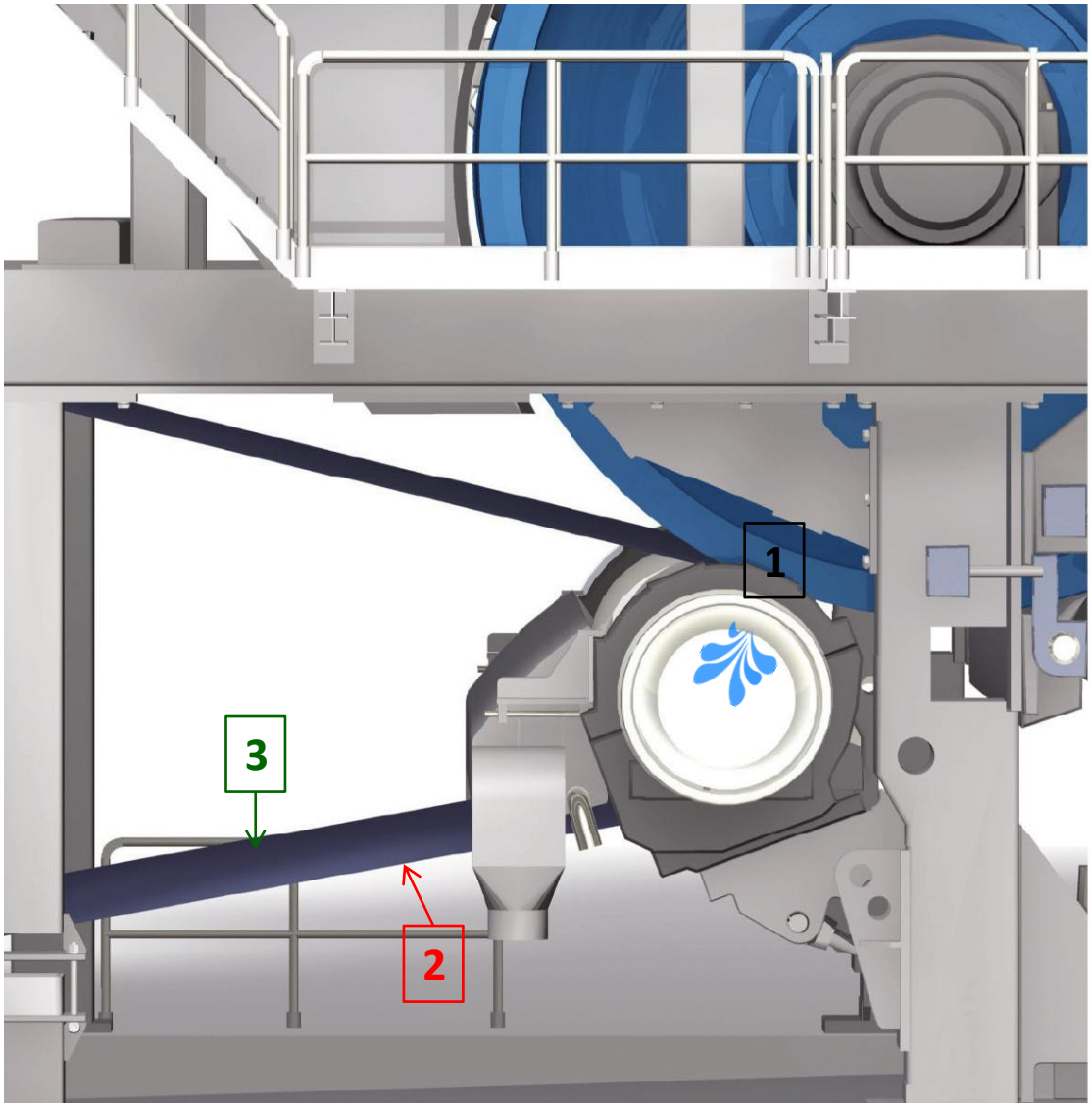
Single-press (SPR) DCT Machine



In the latest high speed (up to 2.000 [mpm]) Single Press (or Suction Press Roll) Tissue Machines the blind holes press (showing very low effect at TM speed ≥ 1.750 [mpm]) has been simply eliminated to "save" some paper bulk accepting a slightly higher drying energy consumption (steam and gas).

The press section also results simpler and "cleaner" than in the double-press design.

Hood shape is normally improved.

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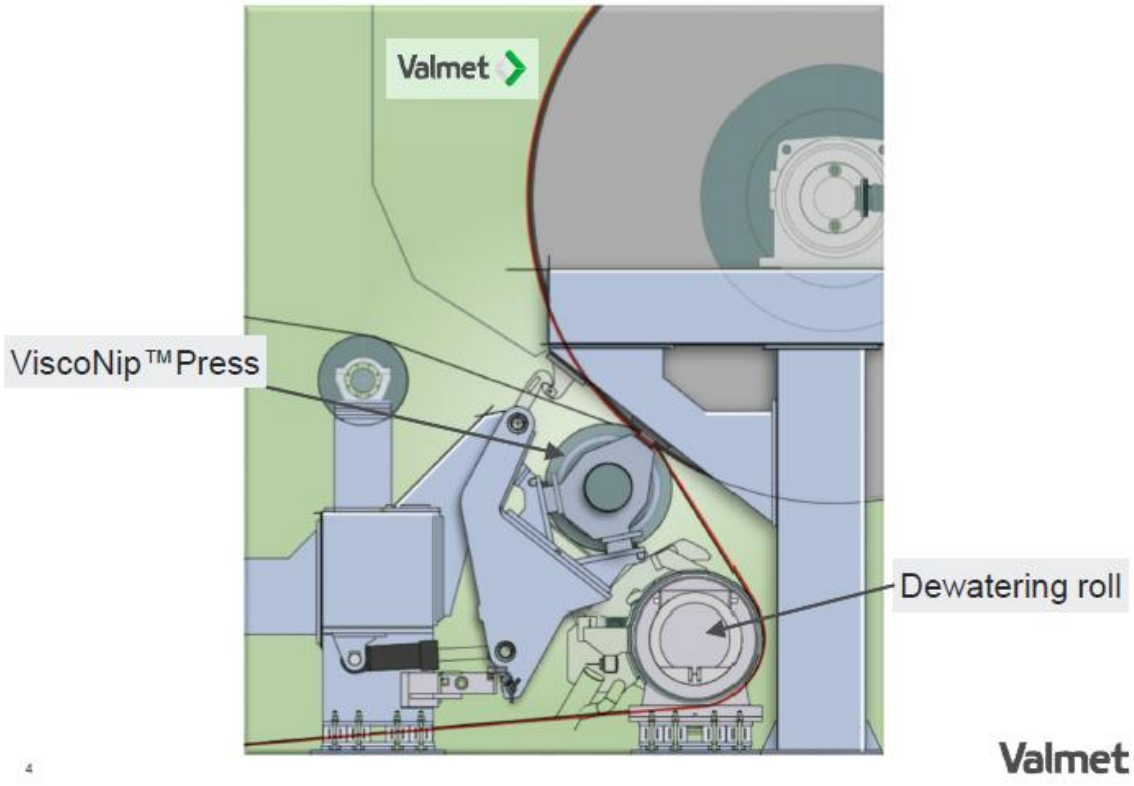
Shoe-press DCT Machine



The shoe-press represents the latest evolution of the pressing (mechanical drying) technology in tissue production.

The “rigid” SPR surface is substituted by a “flexible” sleeve supported, in the press-Yankee contact area, by a “shoe” that gives a controlled and extended NIP finally allowing a lower pressure on the paper for the same pressing energy used: with this technology we have the possibility of controlling (improving) the tissue thickness (bulk) Vs. its dryness.

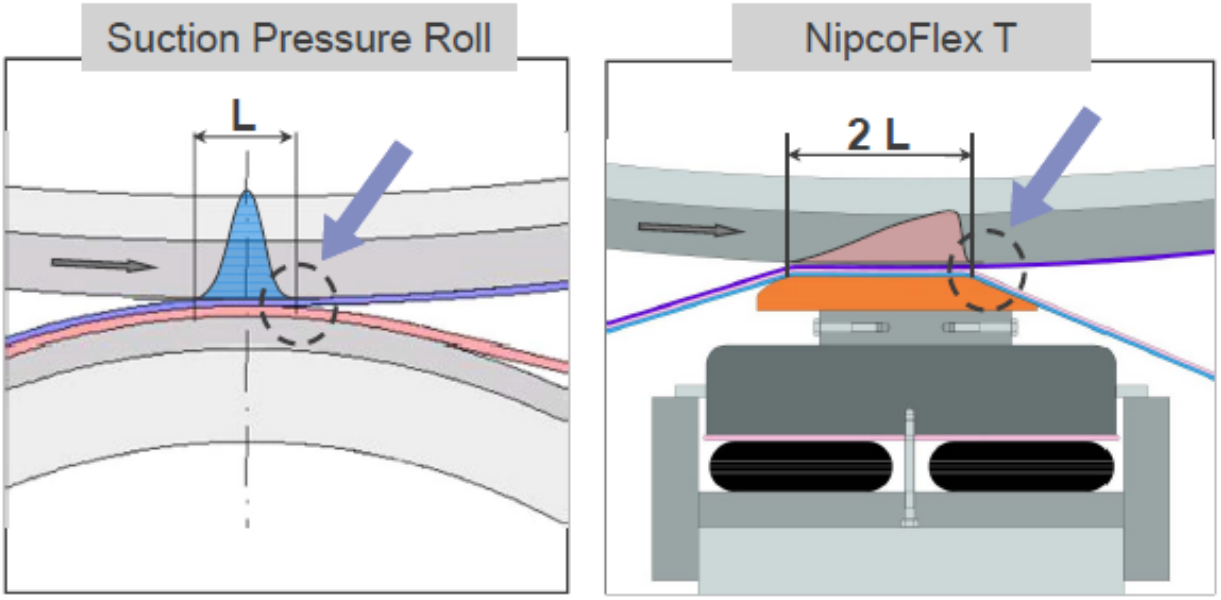
A dewatering roll is installed before the shoe-press itself.

SPR Vs. shoe press: operating principles

Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

Shoe press for tissue Design

- Wider nip leading to higher dewatering capacity
- Longer pressing zone producing better hand feel
- Lower potential for rewetting leading to higher dryness
- Lower peak pressure resulting in higher bulk
- Potential lower maintenance of press cover (sleeve)



- Increased press nip length
- Fast pressure drop at nip outlet – less rewetting

courtesy of VOITH, 2015

The TM dry end

Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

natural gas

In the drying section of TM (Yankee and Hood) water is evaporated to the finished paper dryness (~95%).

The main components of TM dry end are:

- steam heated Yankee drier
- gas fired hood
- steam and condensate system
- boiler

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The Yankee drier

Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

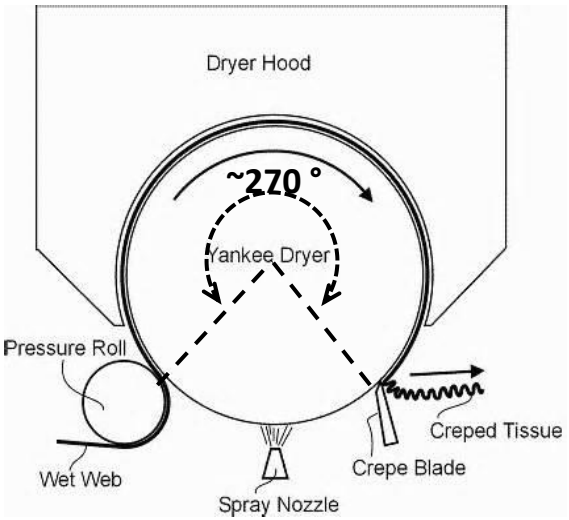
TMs significantly differ from other PMs for the “short” drying section that consist of one single big (up to Φ=6,7 m) drying cylinder that – due to low b.w. - allow the required drying also at high production speeds. The [steel or cast iron] Yankee is required to have shell uniformity, high mechanical strength, resistance to thermal stress, high thermal conductivity, wear and corrosion resistance, minimal microscopic porosity (roughness ~0,1 μm).

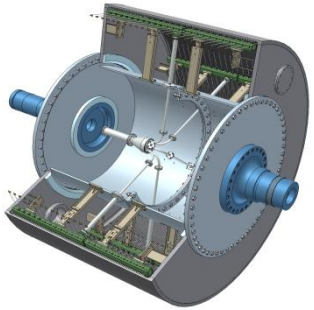
The total heat transferred from Yankee to paper:

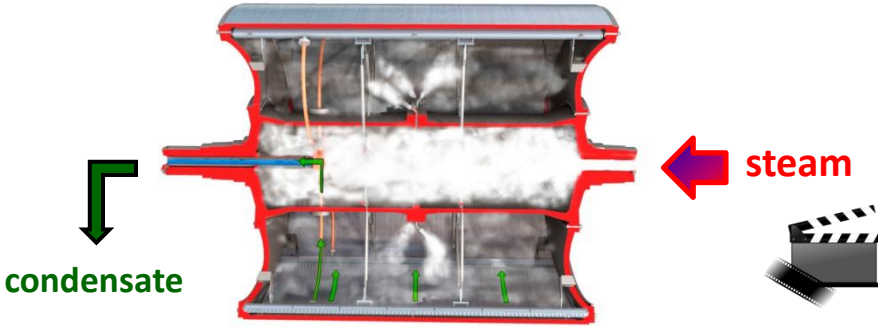
$$Q = K \times S \times \Delta T$$

depends on **S**=heat exchange surface (winding angle), **ΔT**=overall temperature difference between paper and steam, and **K**=overall heat transfer coefficient.

The overall heat transfer coefficient results from the sum of the steam to internal shell surface (condensate layer and extraction), through the shell (material type and thickness) and external shell surface to paper (correct paper adhesion to the surface) ones.







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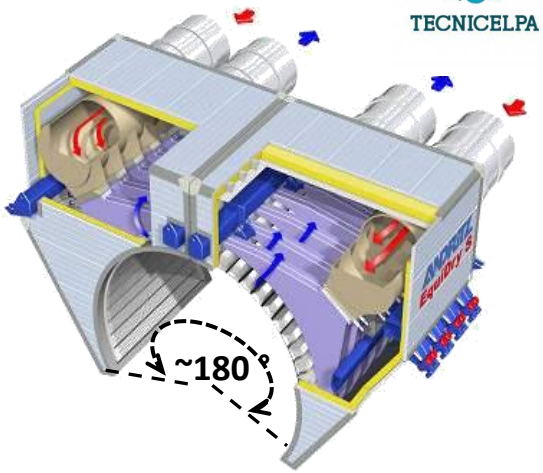
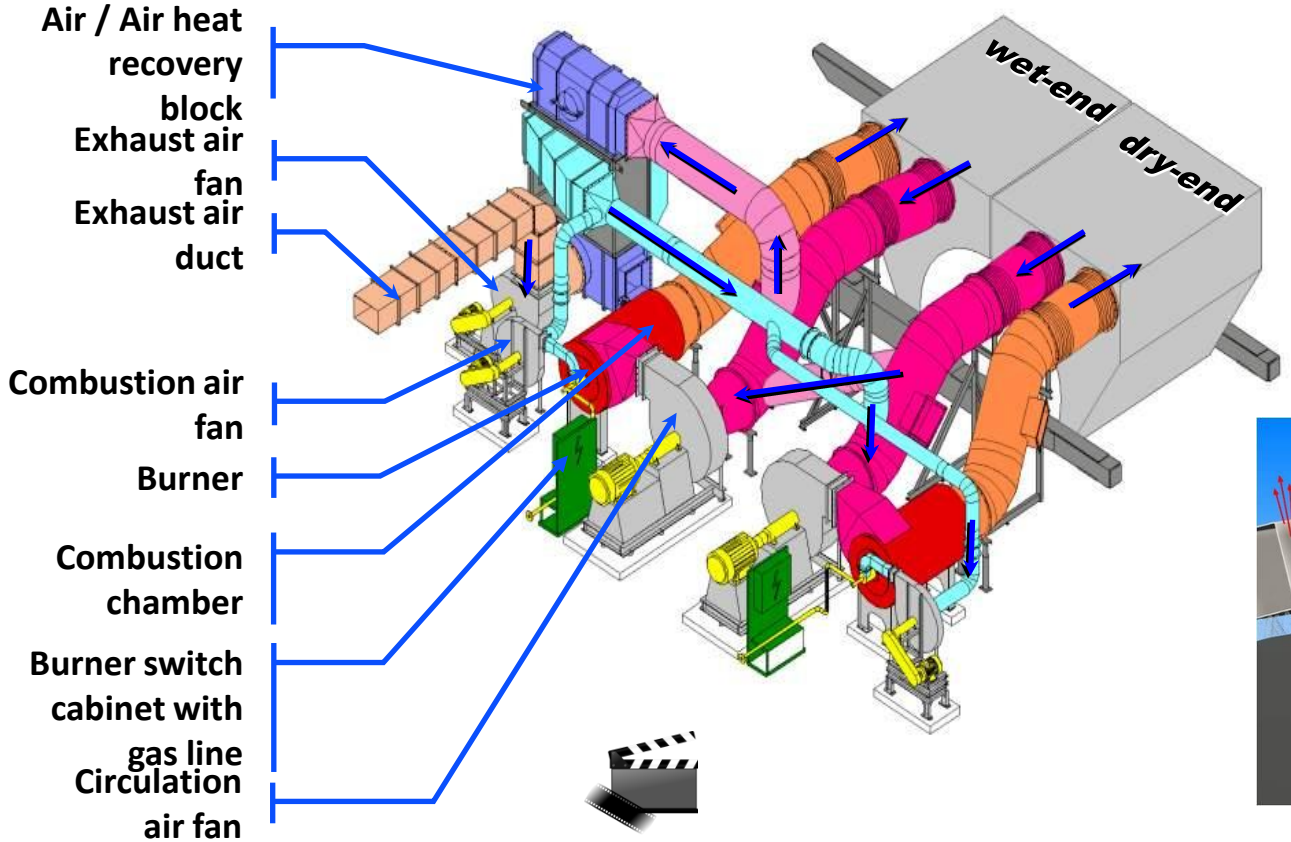
The Yankee Hood

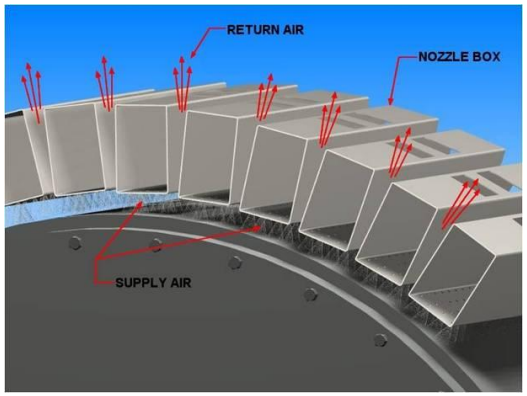
Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

Both Yankee and [wet-end and dry-end] Hood contribute (~50%) to paper drying.
Air heated up burning natural gas is blown (@ ~500°C) to the Yankee-Hood (~20 mm) air gap impinging on the paper web.





Part of the wet air is recirculated and part is discharged to the atmosphere after heat recovery

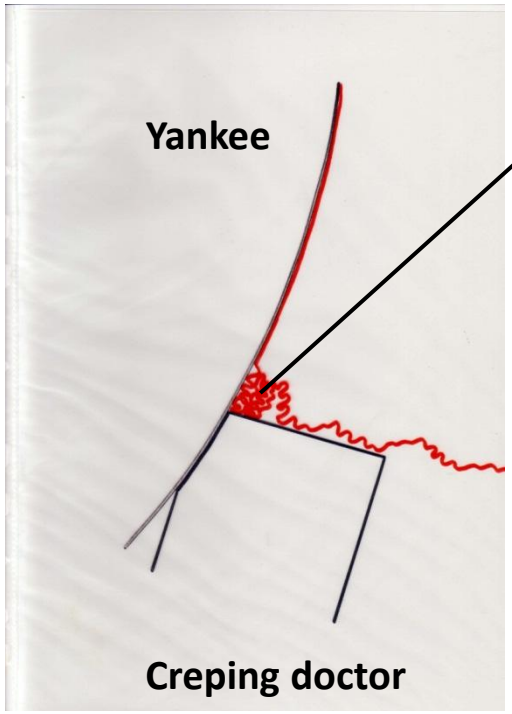


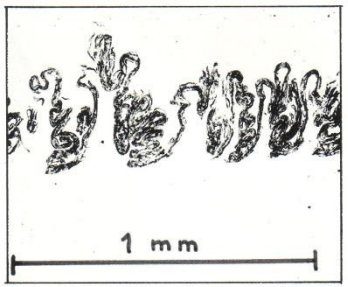
enrico galli, 2017

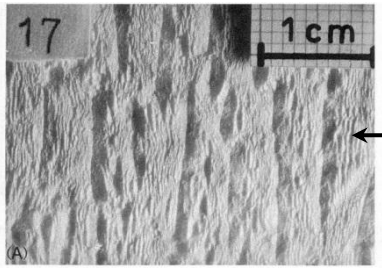
Creping

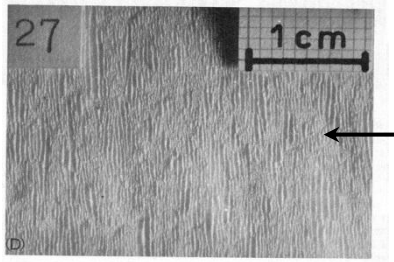
Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

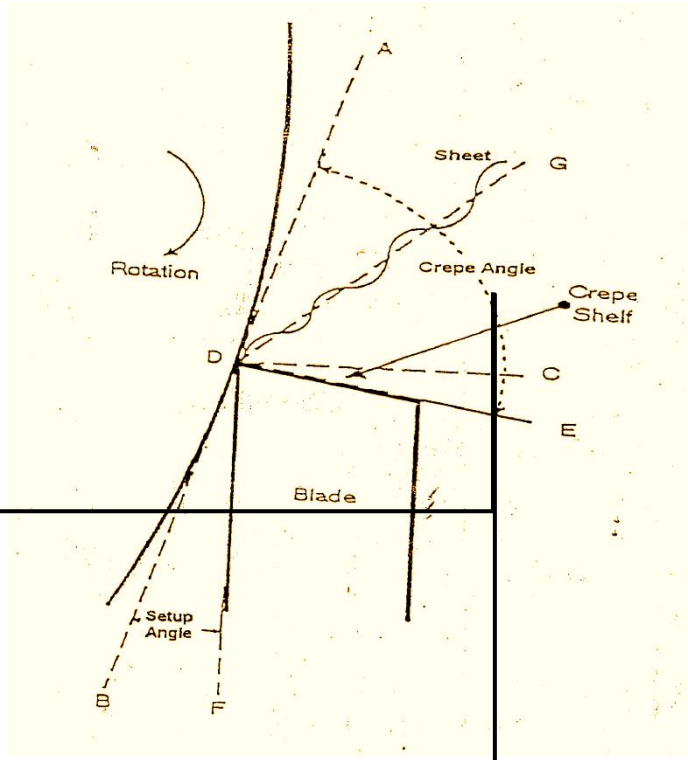
Tissue paper crepe is obtained through an oscillating creeping blade (doctor) that tears out the paper from the hot Yankee surface. Creping depends on paper adhesion to the Yankee and on doctor geometry.











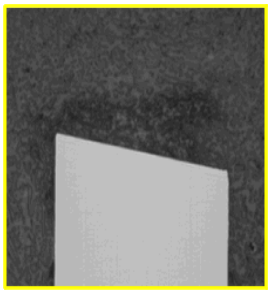
Source BTG Eclépens S.A

Creping

Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

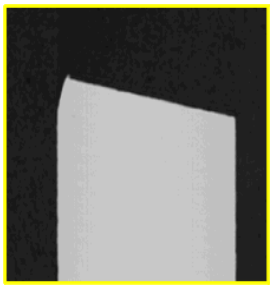
In TM there three doctor holders for cut-off doctor (used during creping doctor changeover), the creping doctor itself and the cleaning doctor (to keep the Yankee surface clean and ready to receive the new paper web from press section).

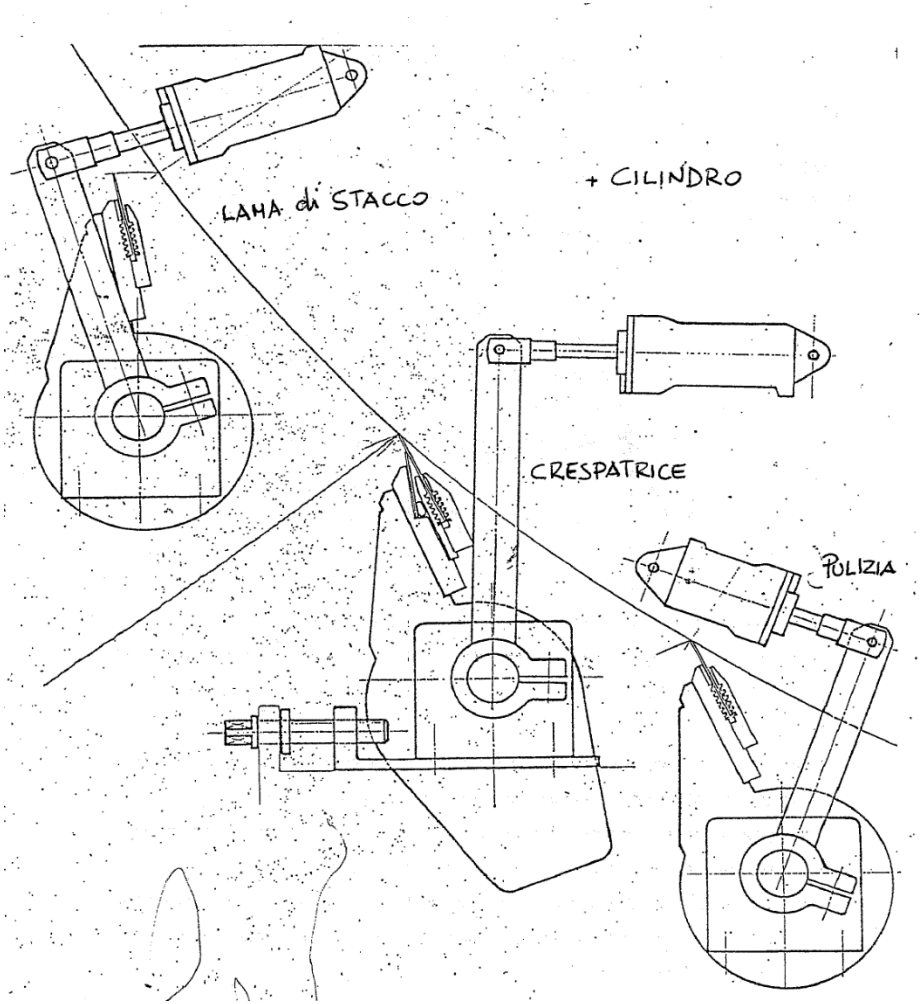
Creping doctor changeover affects TM's efficiency but worn doctor blade reduces paper "softness" .



<- new

worn ->





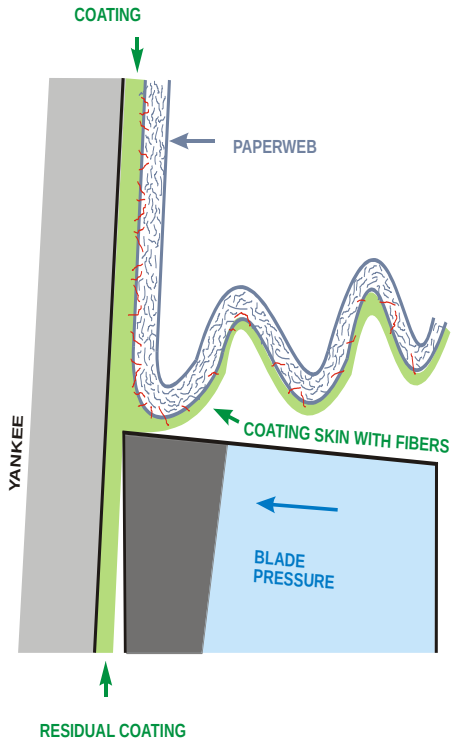
enrico galli, 2017

Coating

Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

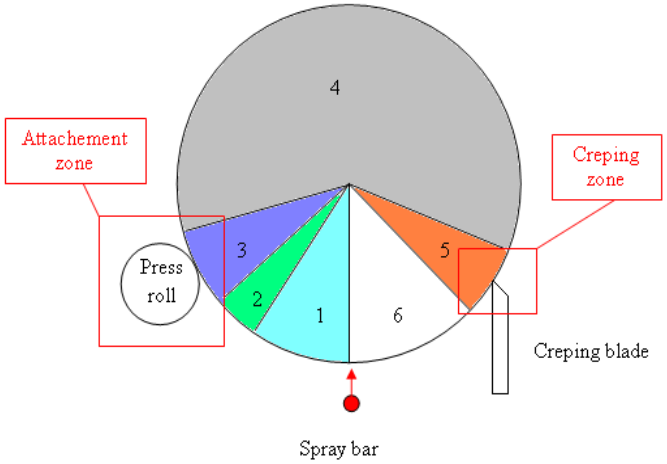
Wet web adheres to Yankee thanks to capillarity and the dry paper adhesion to the Yankee strongly depends on fibers characteristics (hemicelluloses, lignin, contaminants in dip) as well as on Yankee surface (roughness, temperature, material), web humidity and water characteristics (pH, chemicals).

Coating is then used to control the adhesion process: adhesion and releasing chemicals are sprayed on the Yankee surface to create a know adhesion patina.



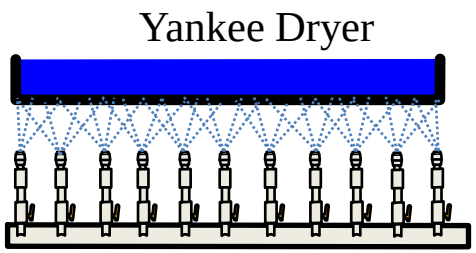
Stages in Coating formation

1. Coating dehydration
2. Crosslinking (crosslinking base coating)
   Tacky coating formation (non crosslinking base coating)
3. Rewetting
4. Drying
5. Doctoring
6. Cured (dry residual coating levelled by the cleaning blade



Coating Chemicals:

- Base Coating
  - Adhesion/Protection
- Modifier
  - Softens Coating and/or Reduces Adhesion or Increases Adhesion
- Release
  - Reduces Adhesion

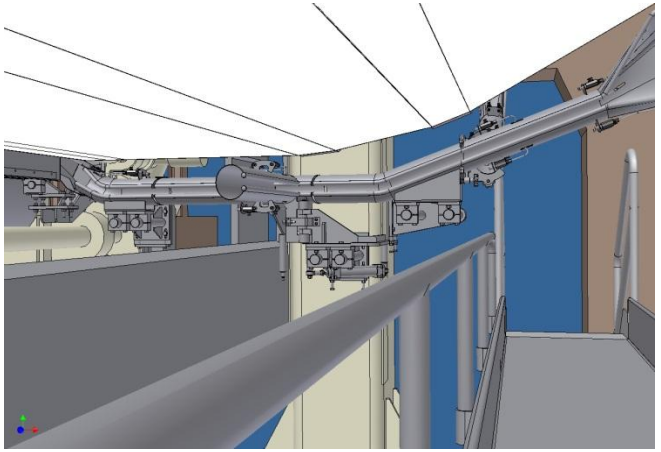


Source BTG Eclépens S.A

Pope reel

Tissue Machine		
headbox	press section	creeping
formation section	Yankee & hood	pope reel

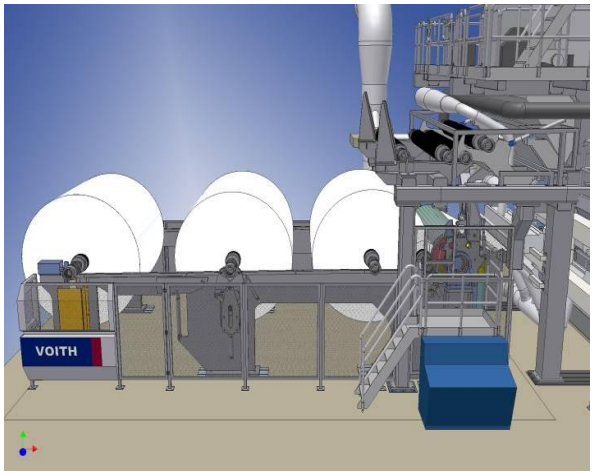
The Pope Reel is the last component of the TM where the JR is formed: the creped paper web is carried through air blows to the b.w. and moisture control system and then to the pope: paper is winded on a board core contrasting with the pope reel itself.



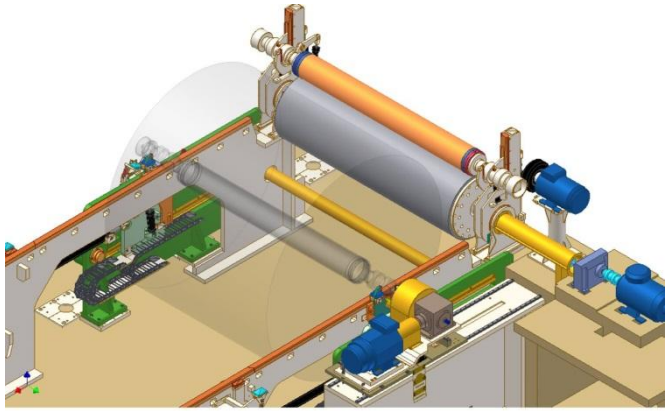
The pope has a winding speed lower that the Yankee's one not to "destroy" the creeping of the paper; this speed difference defines the elongation usually also called creping (14%÷24%):

$$\textbf{Creping} = (V_{Yankee} - V_{Pope})/V_{yankee}\ [\%]$$

As TM's production is calculated as paper produced (on the Pope!) with the same TM's working conditions and the same paper grade higher Creping means lower production.



To get an uniform JR density arms are used to modulate the approach of the growing JR to the Pope reel. The finished JR is automatically replaced by a new empty core.



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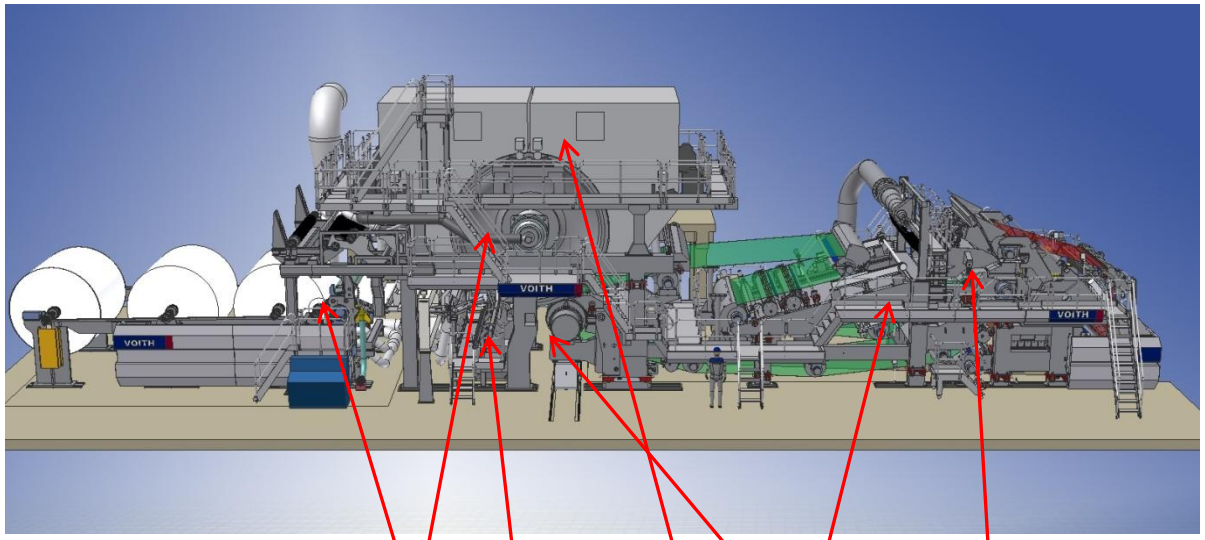
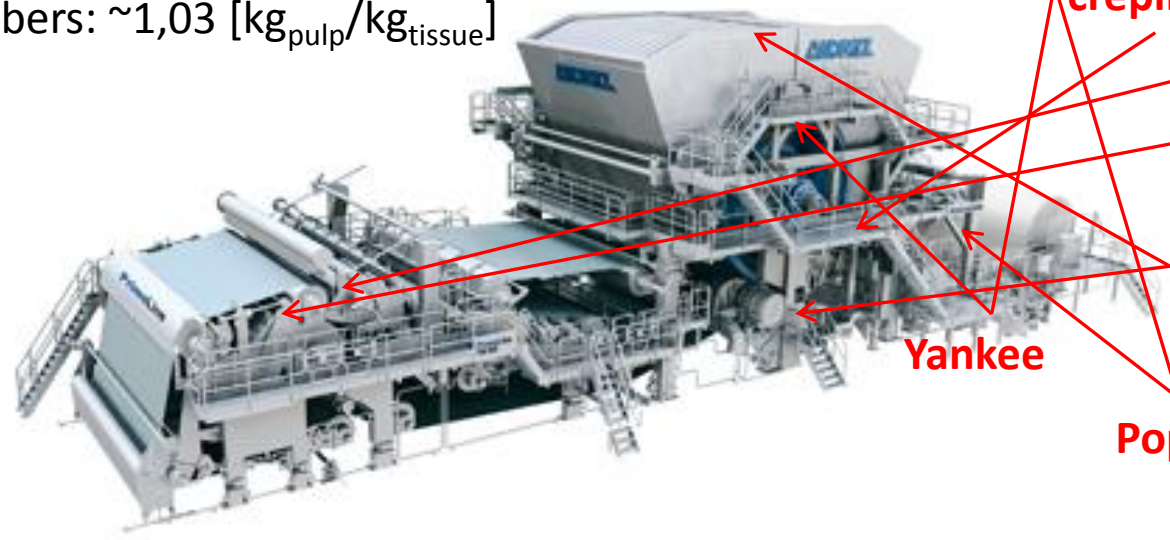
TM: summary & typical figures

State of the art TMs main figures

Crescent former (felt & wire former)
Width [m]: single 2.75 - double 5.50
Production speed: up to 2.000 [mpm]
Paper grades: 12 – 35 [gsm]
Daily production: 100 ÷ 200 [t/d]
Two layer headbox
Shoe press (~90 [kN/m])
Steel Yankee Dryer (p_{steam}=8 [bar])
High efficiency gas fired hood
Drying energy (gas): ~1.3 [Kw/kg_{tissue}]
TM + SP energy: ~ 0.9 [Kw/kg_{tissue}]
Fresh water use: ~6-0 [l/kg_{tissue}]
Fibers: ~1,03 [kg_{pulp}/kg_{tissue}]





creping
headbox
formation section
press section
Yankee
hood
Pope

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Tissue paper production: Slitter Rewinder – Combiner (SR)

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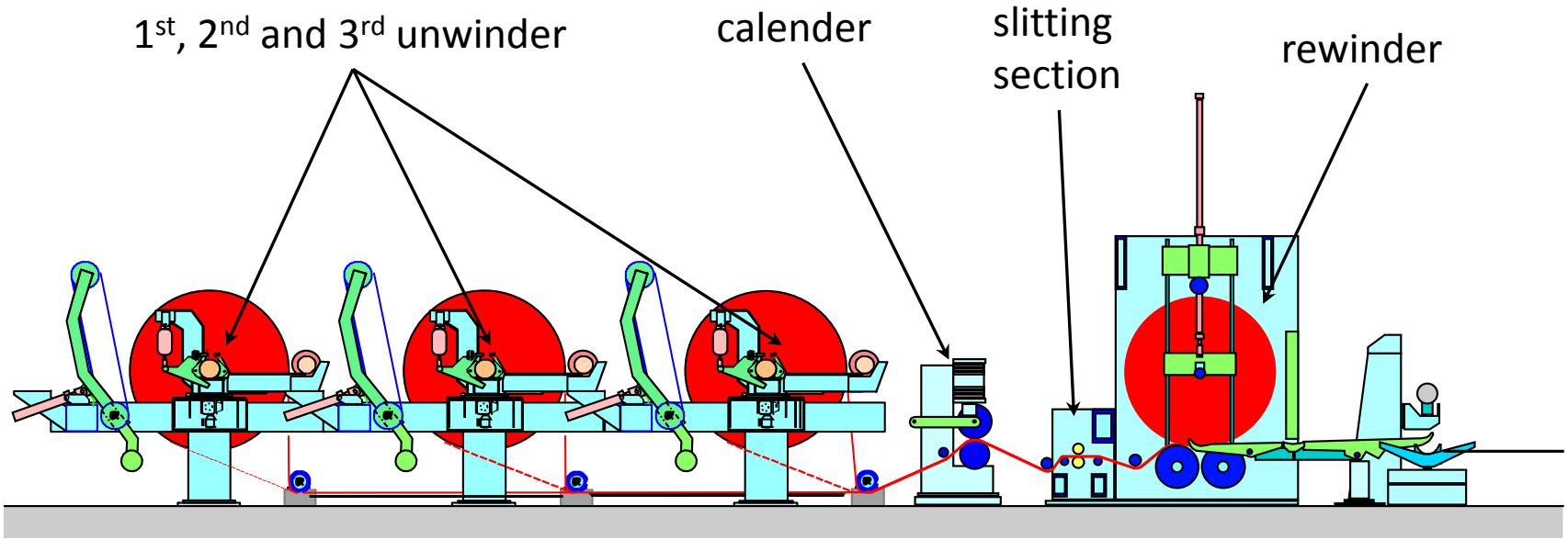
Slitter rewinder (combiner)

The one layer JRs produced in TM may be directly used in converting lines, but very often due to f.p. characteristics and/or converting machines dimensions multiple layers and different size (wide and diameter) JR are required: two ore more one layer JR from TM are then ***combined*** [in two ore more layers] one, ***slit*** to the required width and ***rewound***.



Main SR's features are the unwinders control (to reduce as much as possible the creping losses) and the uniformity of the rewound roll density (controlled through a riding rolls with the same function of the Pope's arms).

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Tissue paper rolls converting

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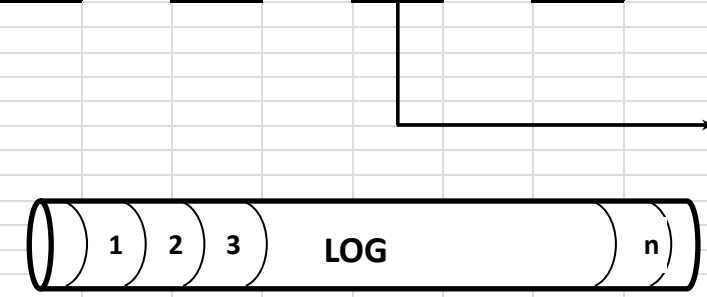
Rolls converting production cycle

PACK (Consumer Unit)

BUNDLE (commercial unit)

PALLET (logistic unit)



strech plastic film
wooden pallets
plain plastic film
handle material
print plastic
tail seal glu
pick-glu
decoration (glue) ink
lamination glue
printing inks
Row Material Tissue JR
1-3 unwinders
printer
embossing & lamination (decoration)
rewinder
tail sealing
accumulator
log saw
wrapper (packaging machine) & handle application
bundler
palletization
wrapping & labelling
stretch wrapper pallets of finished products
cardboard strips
1-3 unwinders
core preparation (winding)
core accumulator
core glue
perfume
trim removal system and press
bales of trims (to recycle to TM)

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Tissue paper rolls converting: core production, rewinder & log saw

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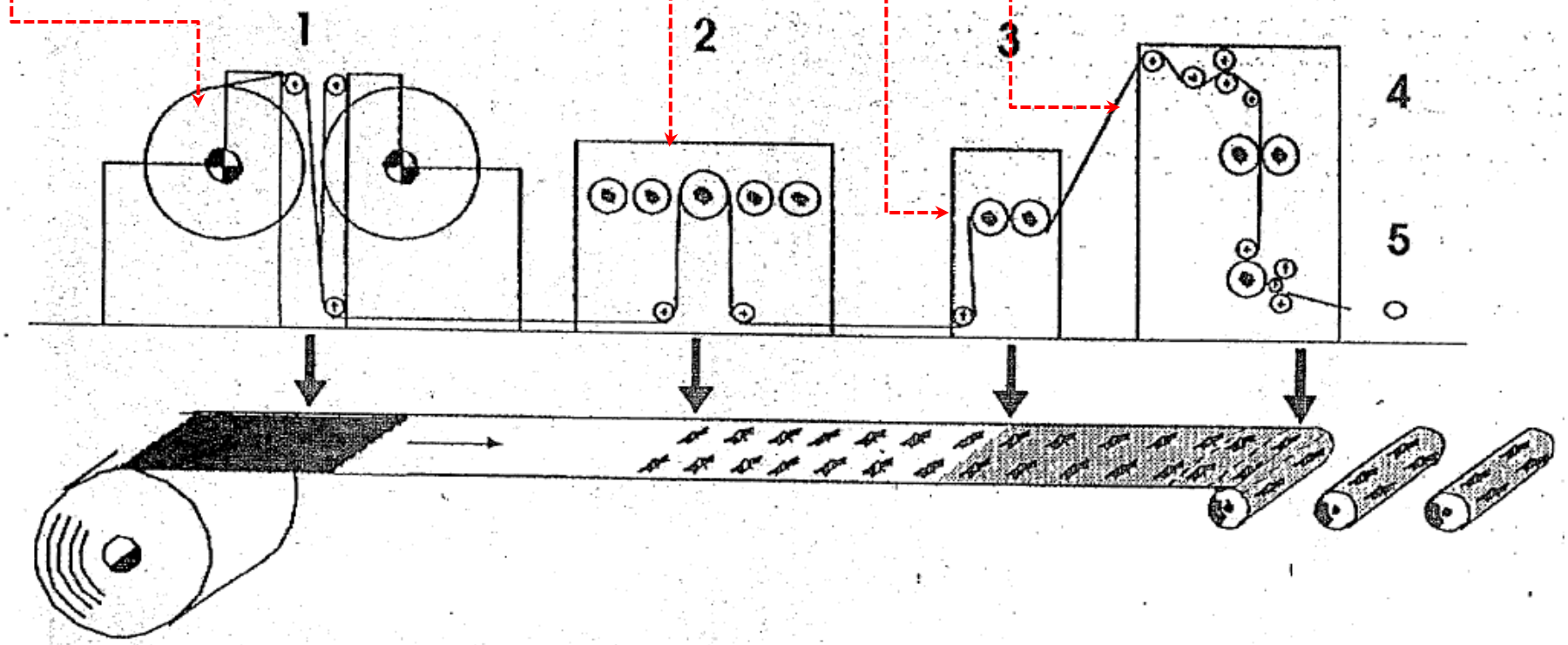
Roll converting: the rewinder

Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw

Paper modification in rewinder:

1. Unwinding
2. 4 colors printing
3. Embossing & lamination
4. Perforation
5. Proper rewinder



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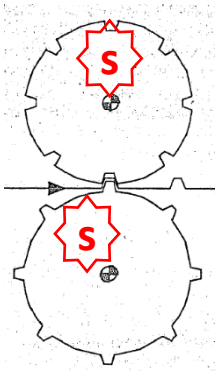
Embossing process

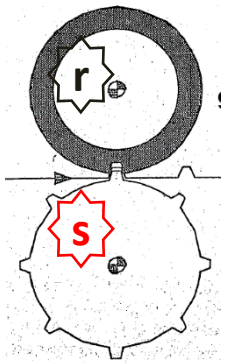
Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw

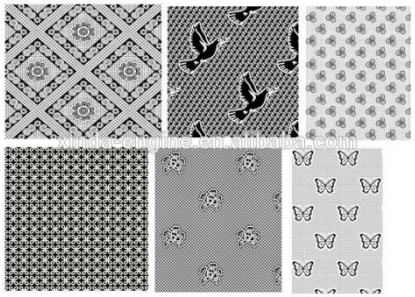
Embossing - the "sculpture" on the paper – is created "pressing" the paper web between two [steel-steel or steel-rubber] rolls.
Embossing has not only esthetical purposes, but also functional (absorption and bulk increase) one as well as ply bonding (lamination).

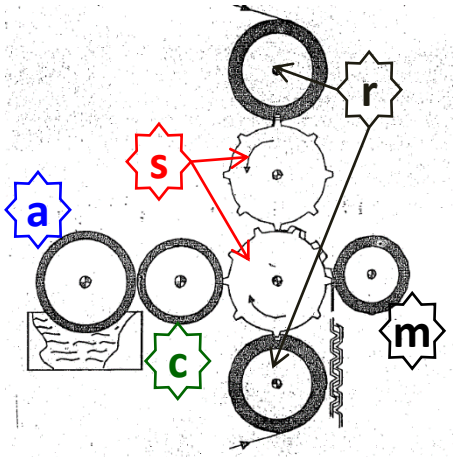
steel-to-steel embosser



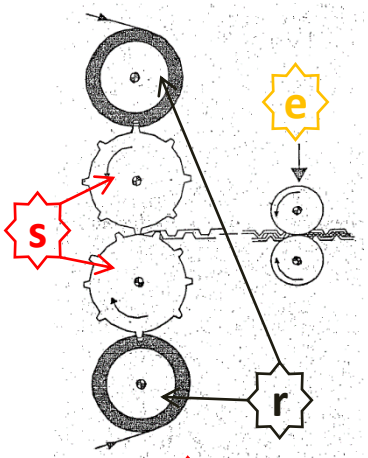
steel-to-rubber embosser



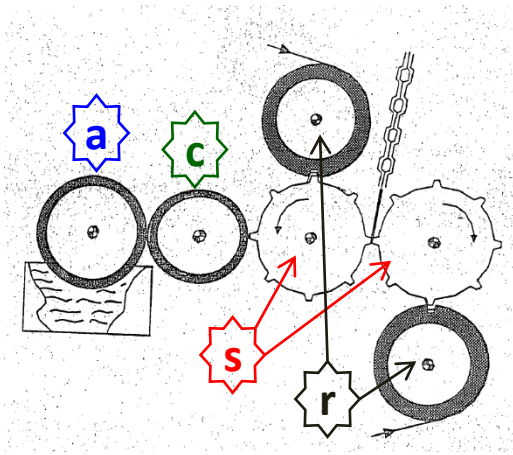




point-to-vacuum (no phased lamination)



Point-to-vacuum (no phased – edge ply bonding no lamination)



point-to-point (synchro lamination)

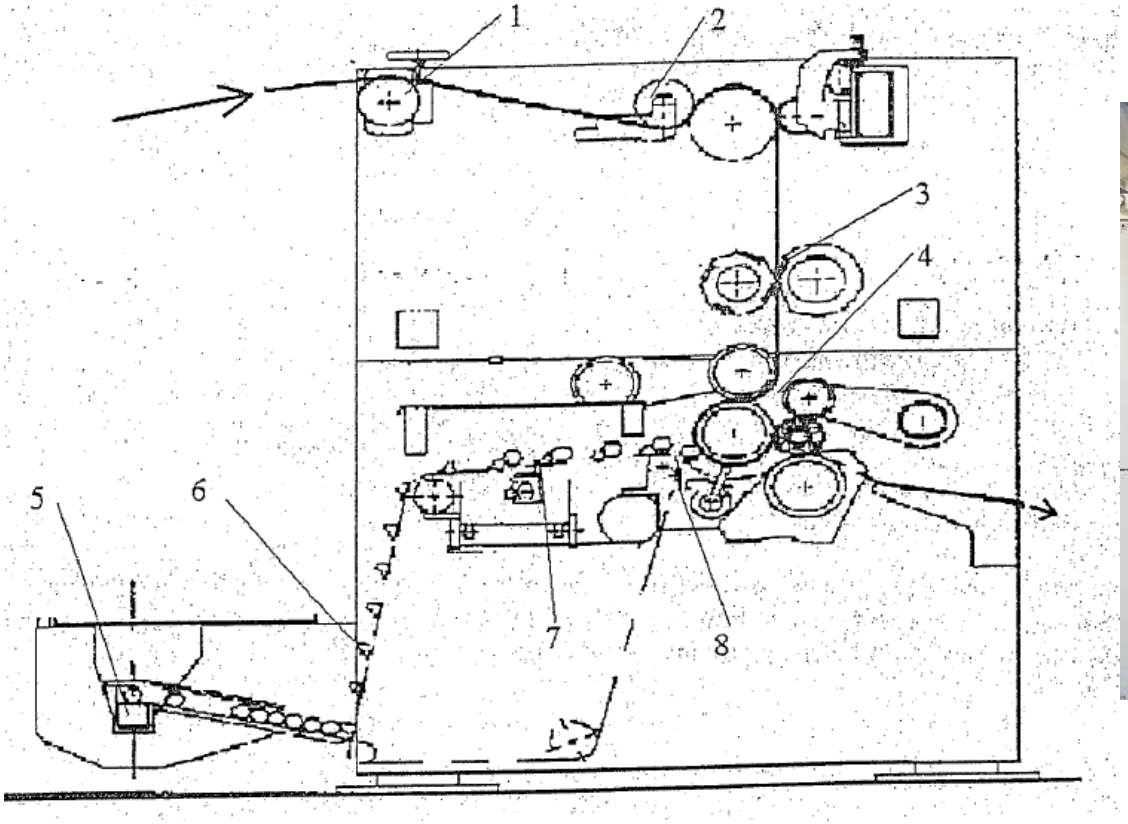
- s — steel embossing roll
- r — rubber embossing roll
- a — anilox
- c — cliché
- m — marring roll
- e — edge embossers

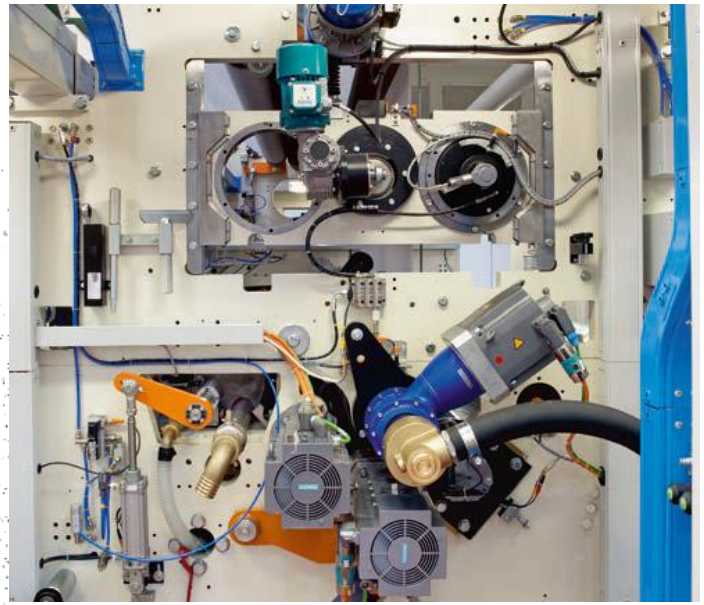
enrico galli, 2017

Perforation and rewinding

Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw

The paper web passes through an opening roll 1 (wrinkles smoothing) and a driving group 2 to the edge embossing unit (if required) and then to the perforator 3.
In the rewinding area 4 paper is wound on the board core produced in the core machine loaded by loader 6 and glued in position 7 with the pick-up glue.

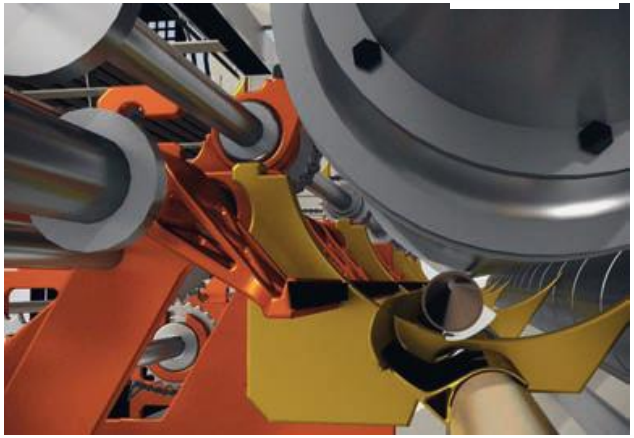




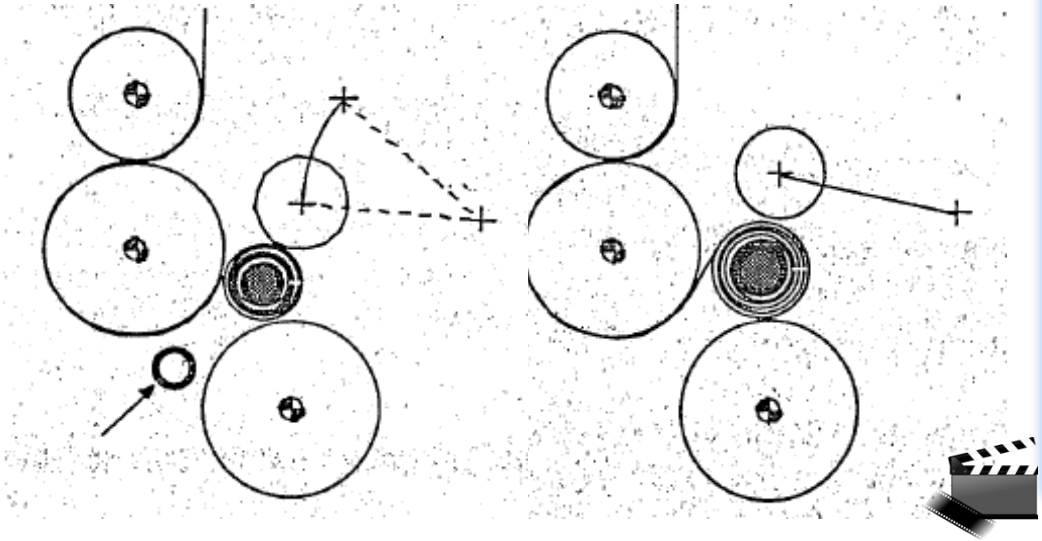
Rewinding

Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw

Core introduction system (detail view – ***source PERINI, 2014***)



The peripheral winding of the paper to the core is obtained putting in contact three rotating rolls with the external surface of the ongoing log.
The core is introduced between two of the winding rolls the third one being dancing (press roll) to allow the log diameter growing.
The "exchange" is the phase when the last sheet of the completed log is separated from the first one that starts winding on the new core to form the new log.

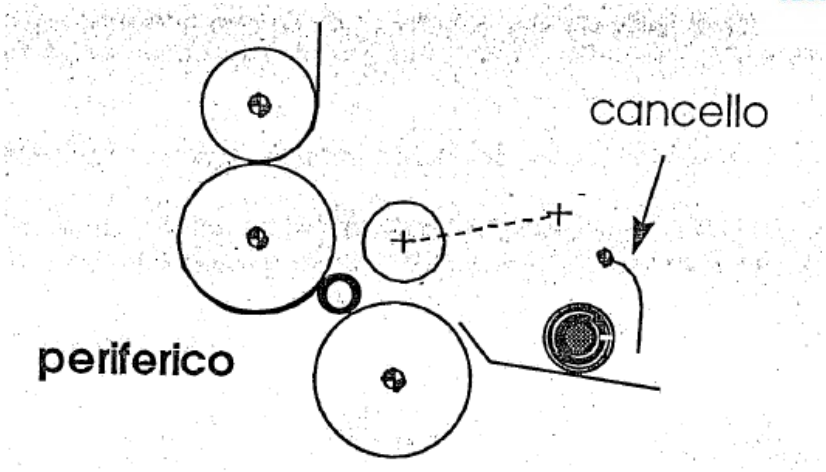


Log formation system (detail view – ***source GAMBINI, 2014***)

Tail sealer

Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw

The completed log is ejected from the rewinder to the tail sealer for gluing with tail sealing glue the last sheet and log closing



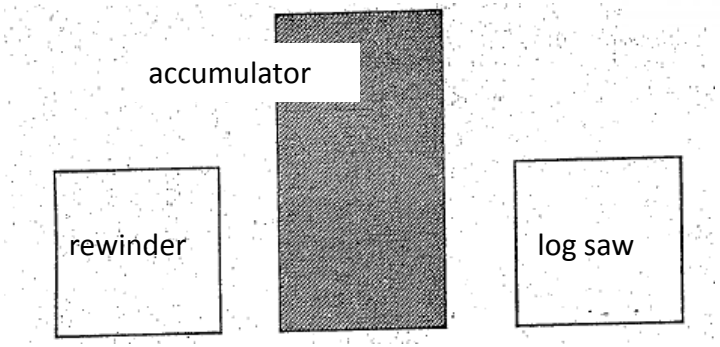
Tail sealing (detail view – ***source PERINI, 2014)***

Tail sealer (overview – ***source GAMBINI, 2014)***

Logs accumulator

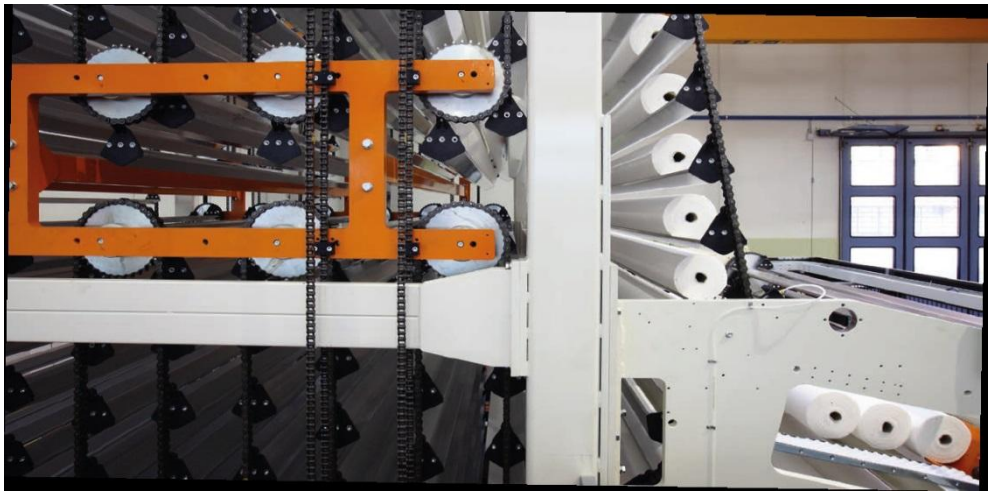
Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw

The logs accumulator main function is to smooth rewinder (log saw) swings due to log saw (rewinder) not constant production



Bucklets (detail view – ***source PERINI, 2014***)

Accumulatore unloading system and logs loading to log saw (detail view – ***source PERINI, 2014***)

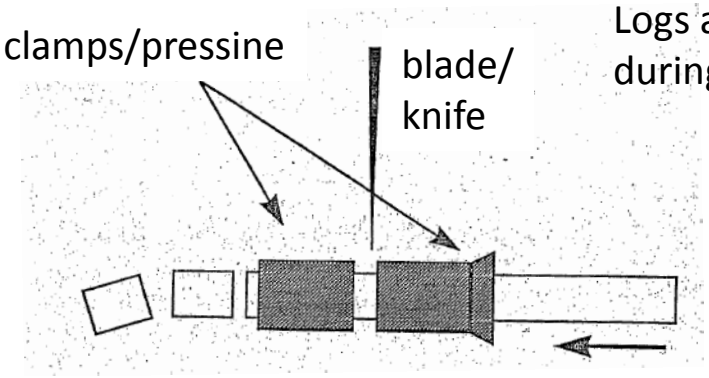


Orbital log saw

Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw

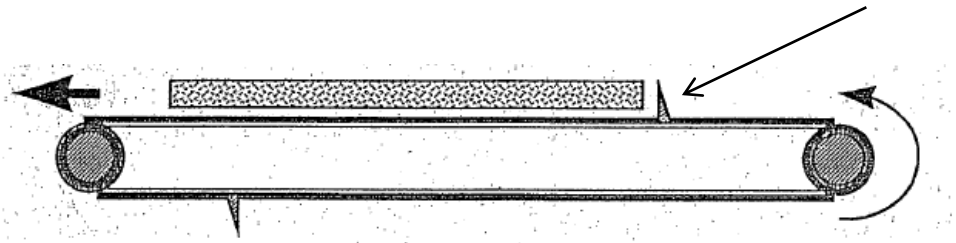
The log saw (to cut the rolls to the required width) can be considered the last operation of converting phase as well as the first one of the packaging.

The cutting element is a rotating circular blade installed on an orbital rotating frame; regular grinding of the blade guarantees the cut quality and shape.

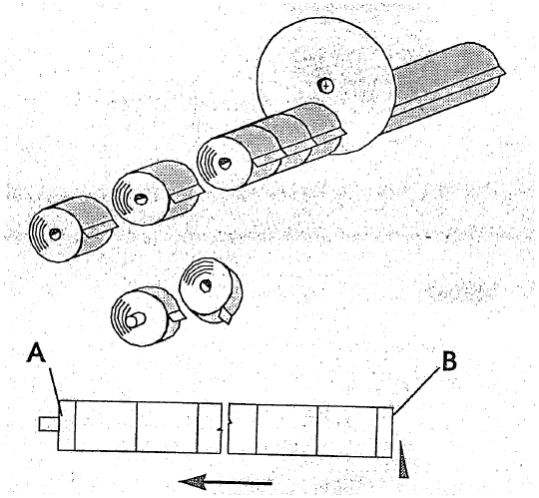


Logs are pushed under the blade and blocked by clamps during cutting process (@ zero differential speed):

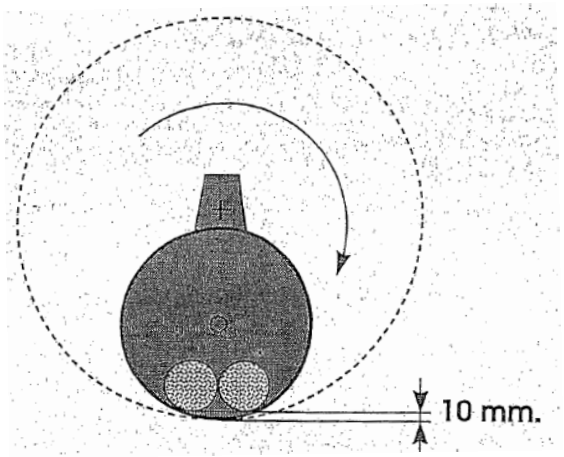
$V_{log} = V_{blade} = 0$ - $\Delta V_{log\text{-}blade} = 0$



Front (shorter) and rear (longer) trims are discharged and recovered (trim removal system) to TM

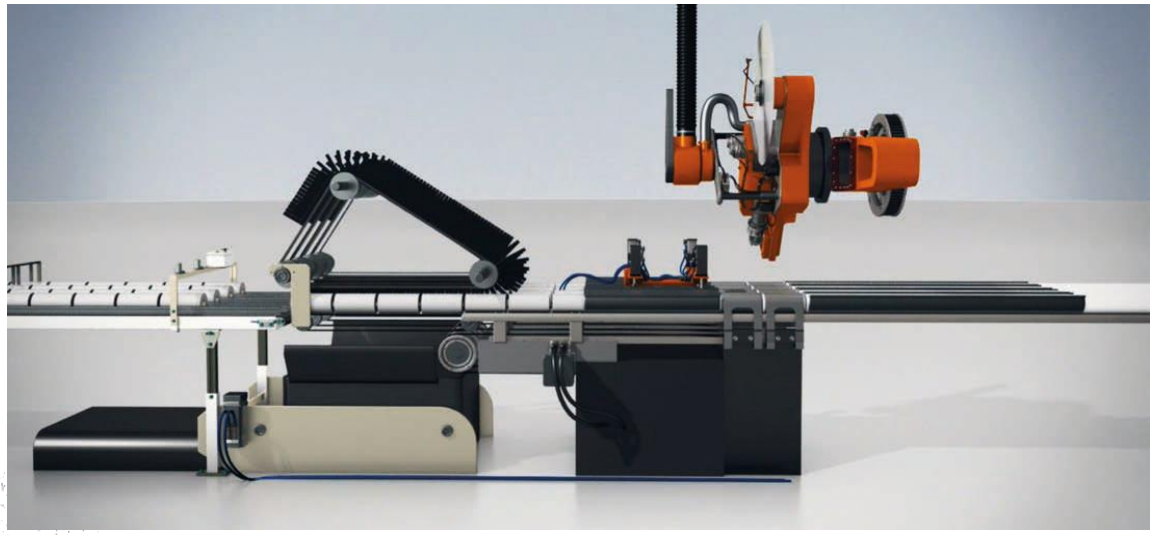


Log saws cut multiple (1÷4) channels (logs) according to their design

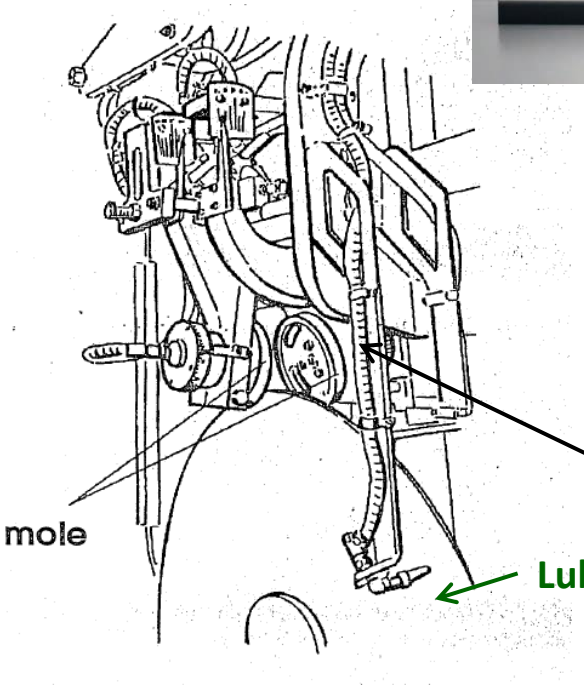


Orbital log saw

Rewinder & log saw		
unwinders	printer	embosser
rewinder & tail sealer	accumulator	log saw



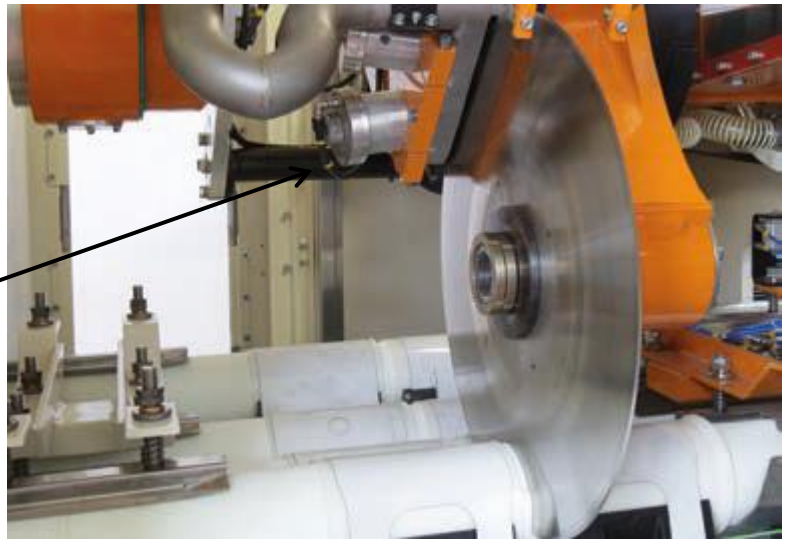
Log saw overview (***source PERINI, 2014***)



Log saw blade is automatically sharpened by grindstones and cooled using lubricating devices.

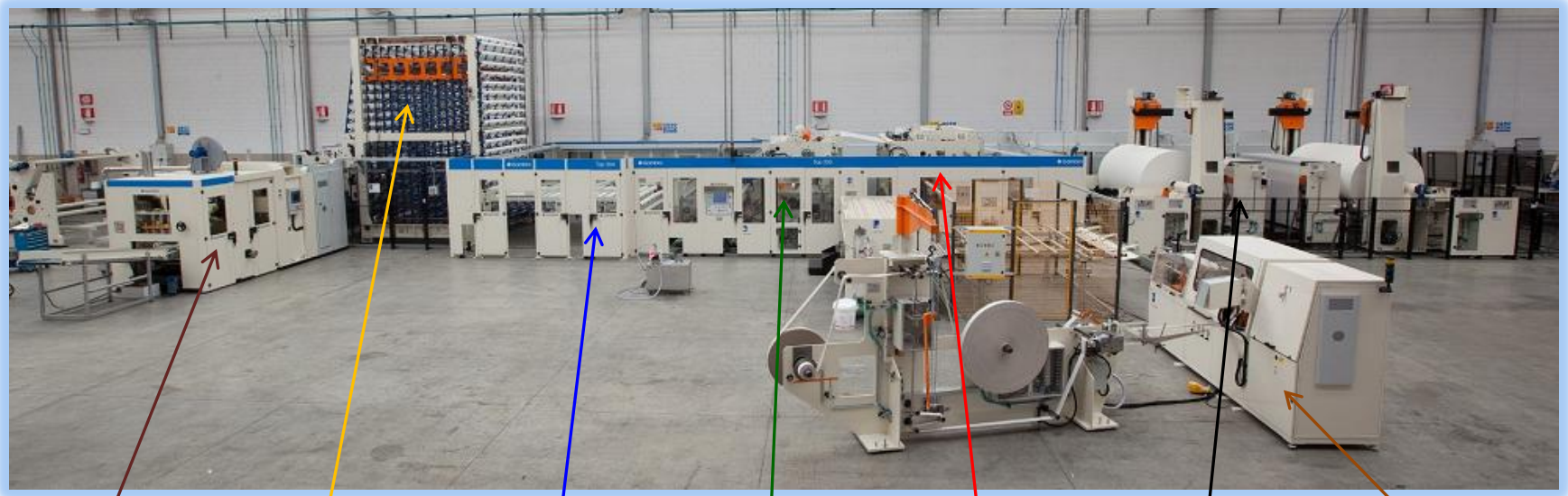
grindstones

Lubrication and cooling oil

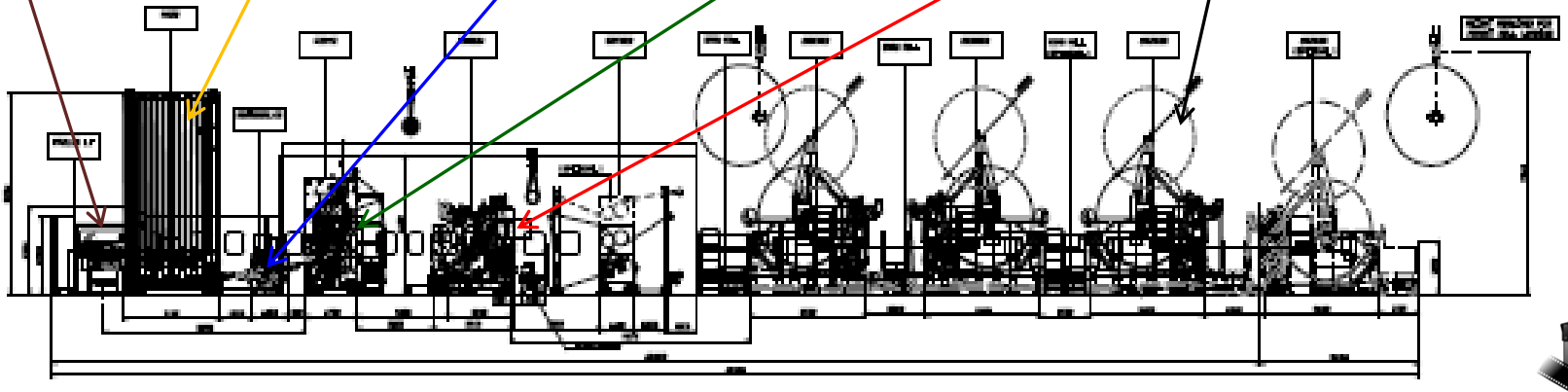


Trims from log saw are automatically removed to remote bailing system

Rolls converting summary: core production, rewinder & log saw



log saw accumulator tail sealer rewinder embosser unwinders core winder



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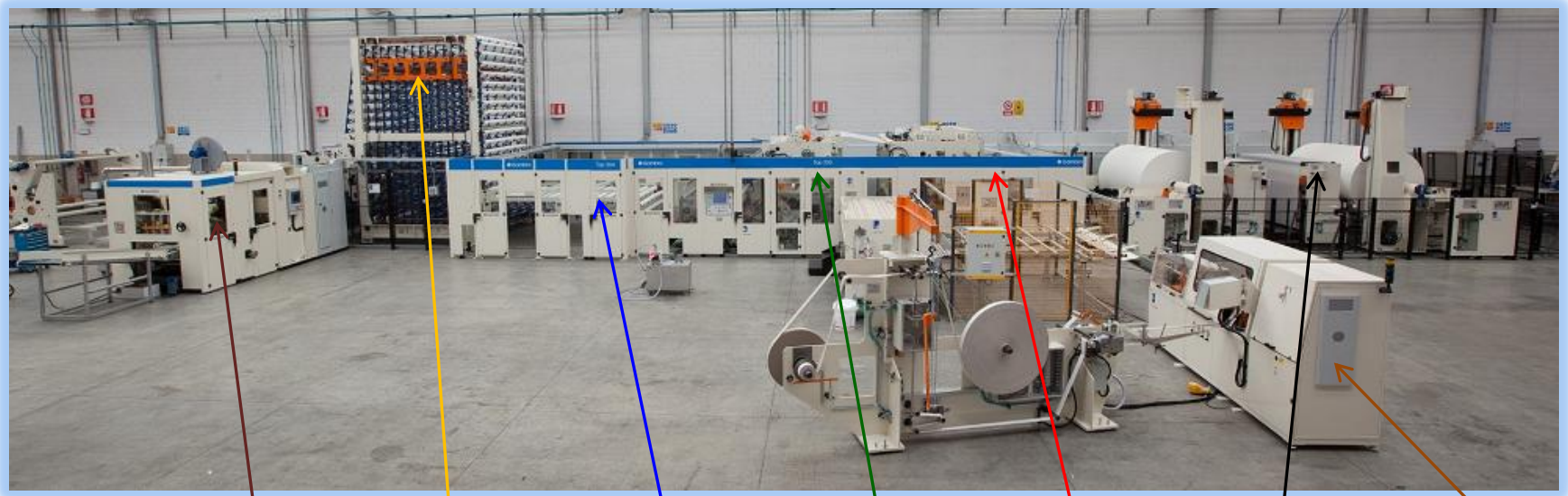
Rolls converting typical figures: core production, rewinder & log saw



	log saw	accumulator	tail sealer	rewinder	embosser	unwinders	core winder
Φ [mm]	160 @4 ch. 200 @2 ch.	100 ÷ 200	-	up to 250	emb.rolls up to 500	up to 3.000	38 ÷ 60
no (logs, ply, colors, channels)	1 ÷ 4 channels	up to 300	-	with/wo pick-up glue	1 ÷ 5 ply	4 belts	1 ÷ 3 strips
features	-	-	Glue, low glue, glue free	multiple perforation	PTP, DESL, DERL, micro	peripheral	
speed [mpm-logs-cuts/min]	up to 250 cuts/min-ch	Discharge up to 60	up to 60	up to 700	650 ÷ 750 with/wo lamination	up to 700	up to 160

enrico galli, 2017

Tissue paper rolls converting: packaging & palletization

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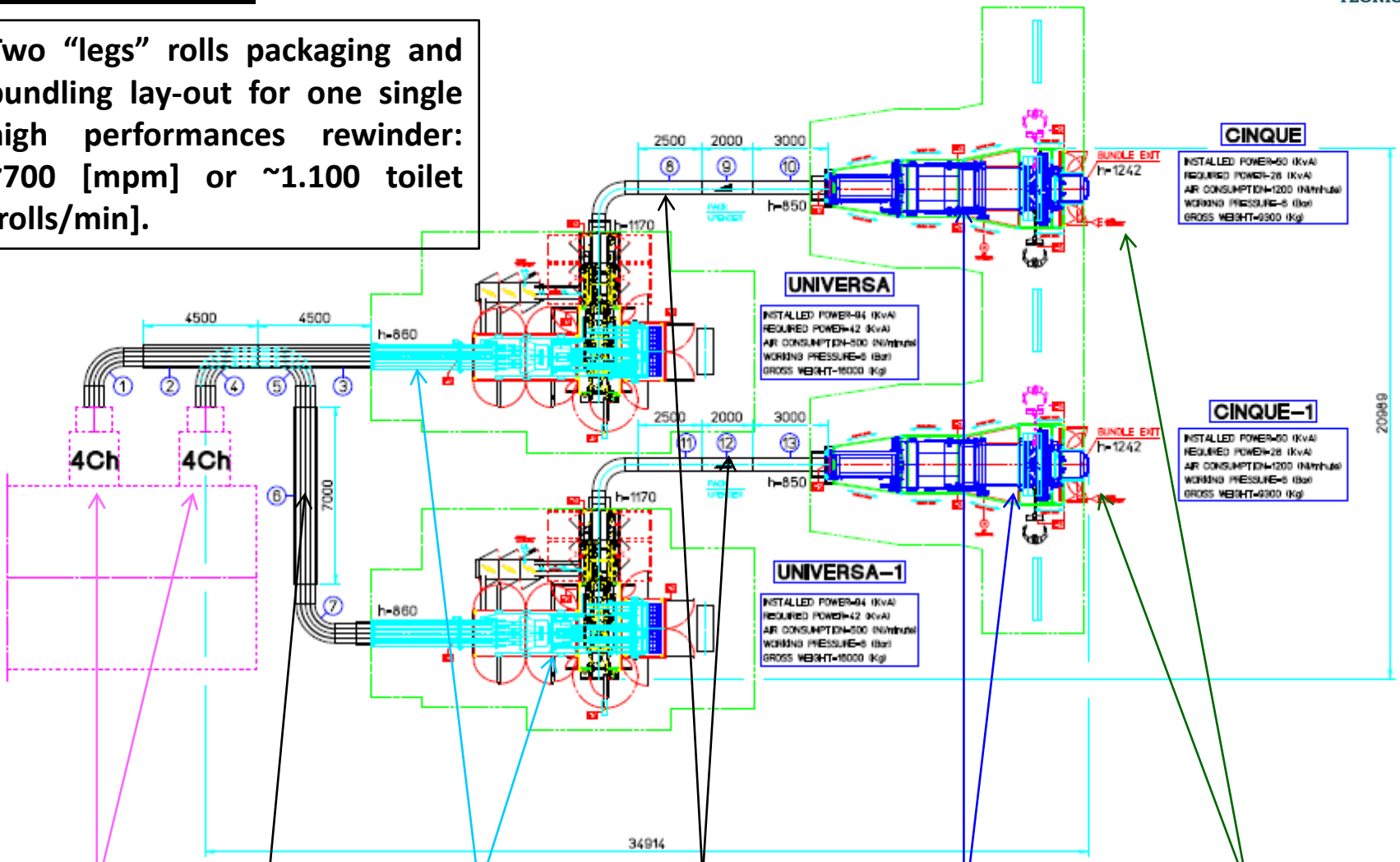
Rolls packaging layout

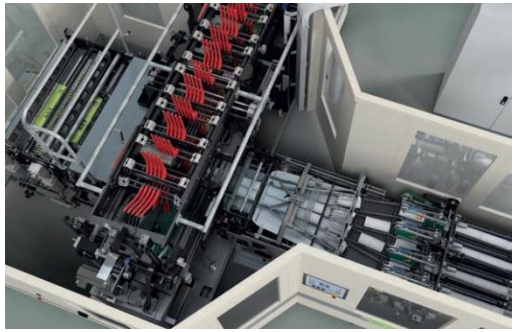
Two “legs” rolls packaging and bundling lay-out for one single high performances rewinder: ~700 [mpm] or ~1.100 toilet [rolls/min].

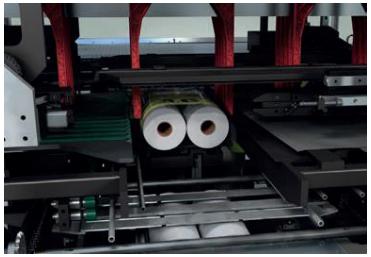


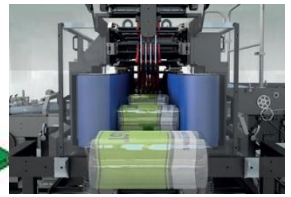
2 four channels log saws	Rolls conveyors	Packaging machines (wrappers)	Packs conveyors	Bundlers	Bundles conveyors (to palletization system)

courtesy TMC, 2015

Rolls packing machine (wrapper)







Foldering group

rolls "douzers" system

second [groups] dragging unit

Out feed sealing unit

in feed launchers system

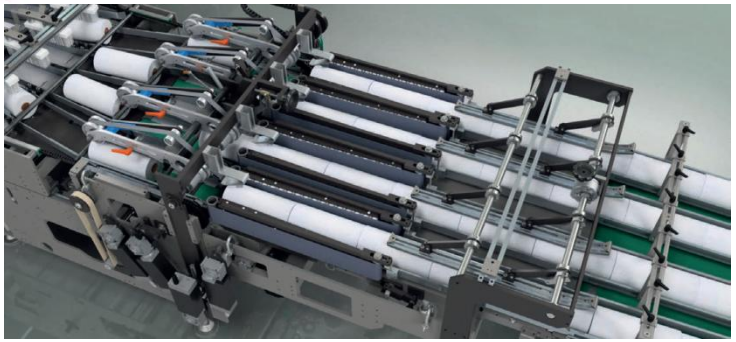
Elevators

PE film unwinding unit

rolls stratifier

rolls infeed conveyor (4 channels)

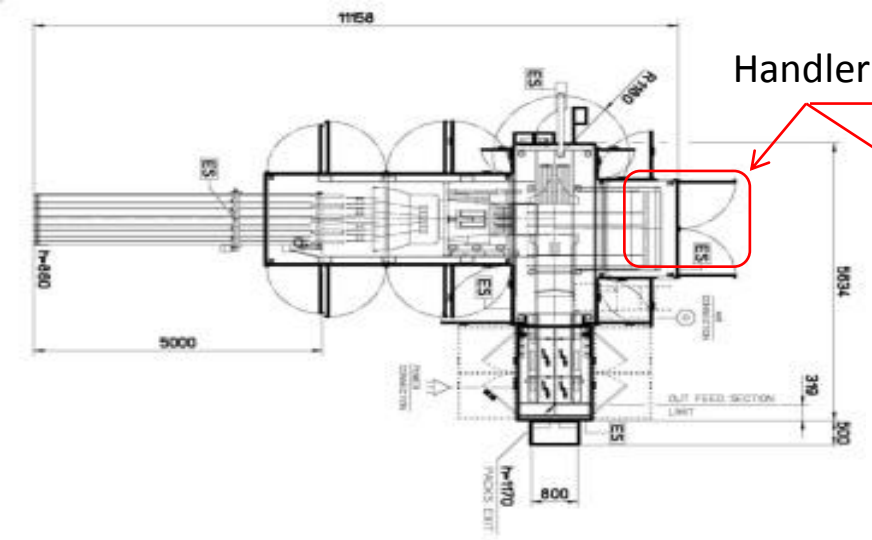
first [lanes] dragging unit



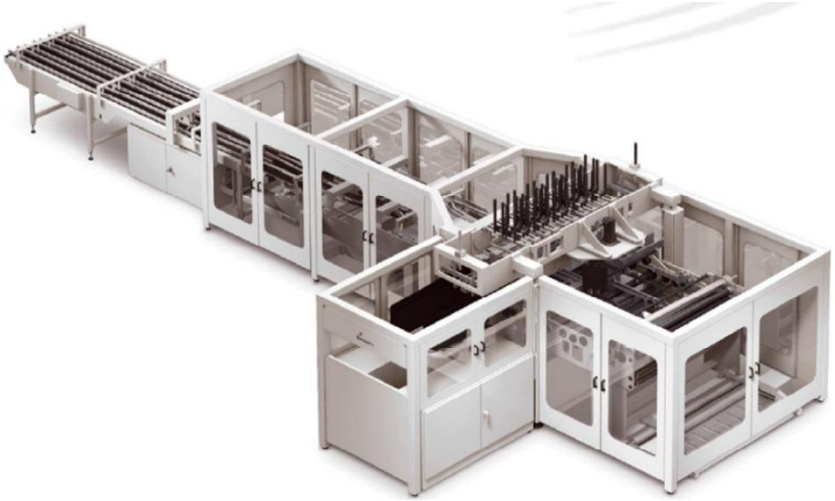
Multipack wrapper (***source TMC***)

- Rolls diameter: 90÷150 [mm]
- Rolls cut-off : 90÷130 - 200÷280 [mm]
- Packs dimension: 90÷600 x 180÷600 x 90÷300 [mm]
- Production speed: 200 [4 rolls toilet ppm] – 20 [48 rolls toilet ppm]

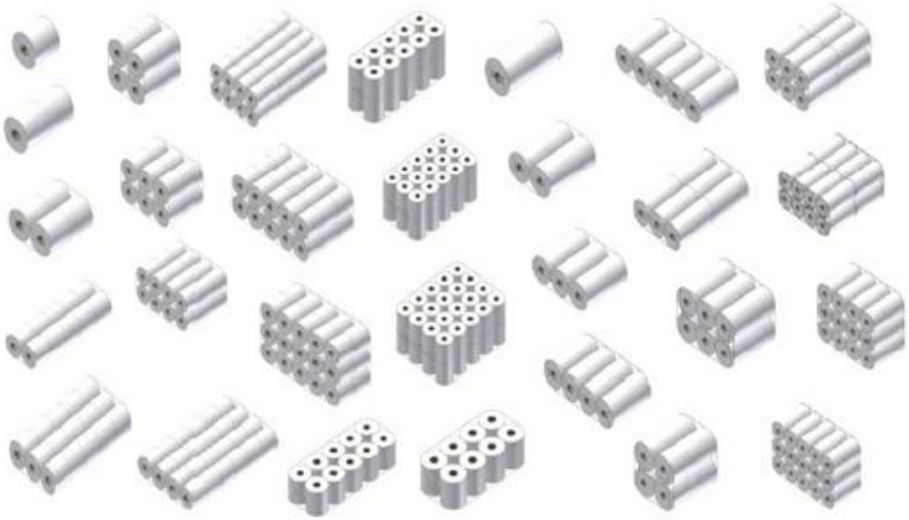
Rolls packing machine (wrapper)



Handler

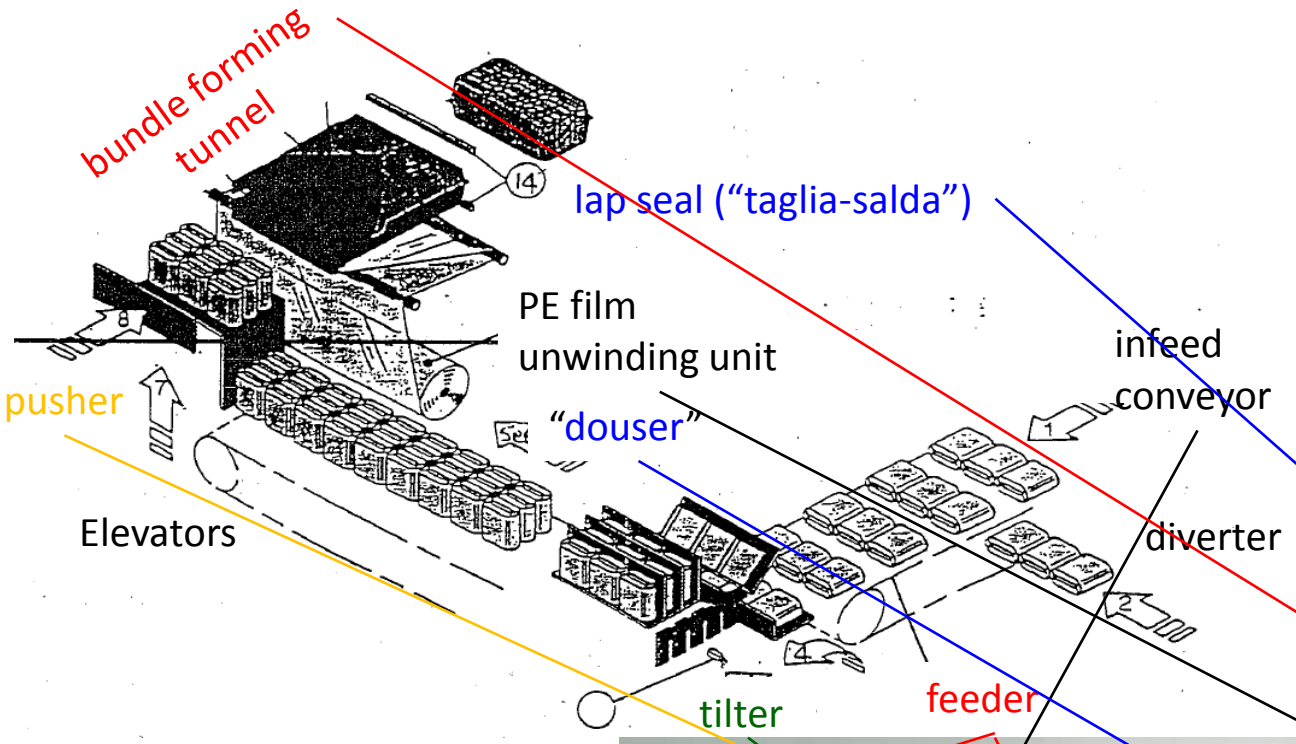


source INFINITY, 2015



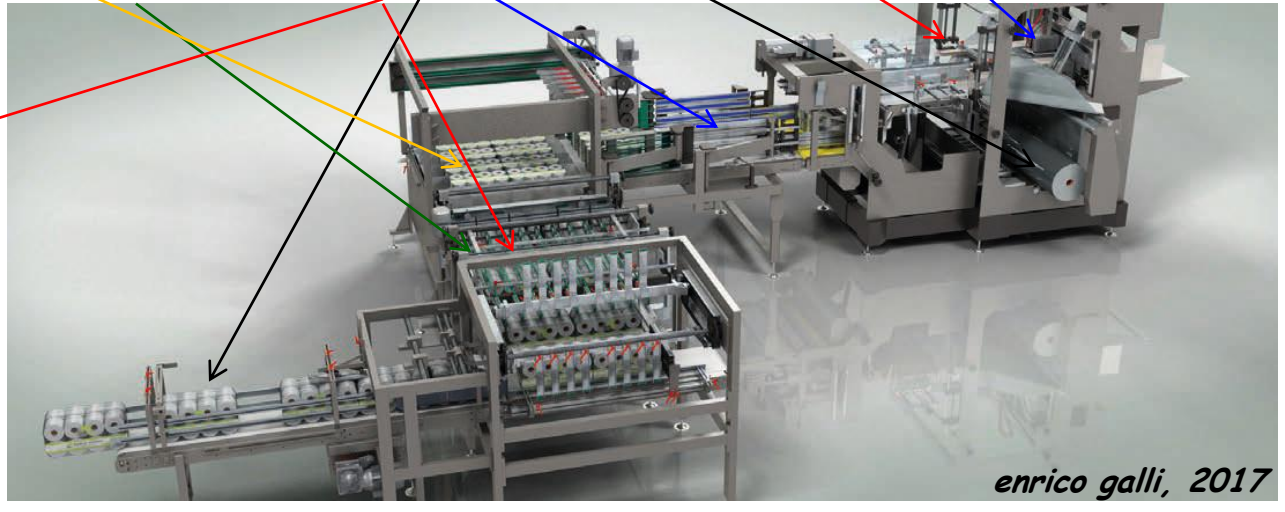
enrico galli, 2017

Rolls packs bundler



Bundler (***source TMC***)

- Bundle dimension: 350÷850 x 200÷1200 x 150÷500 [mm]
- Production speed: up to 25 [bundles/min]



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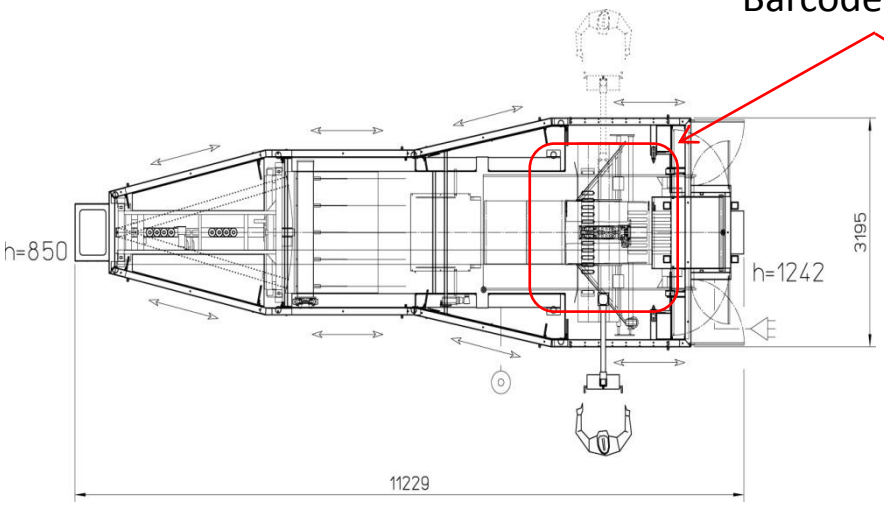
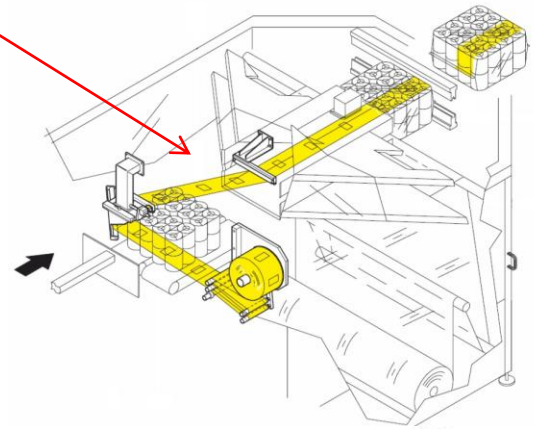
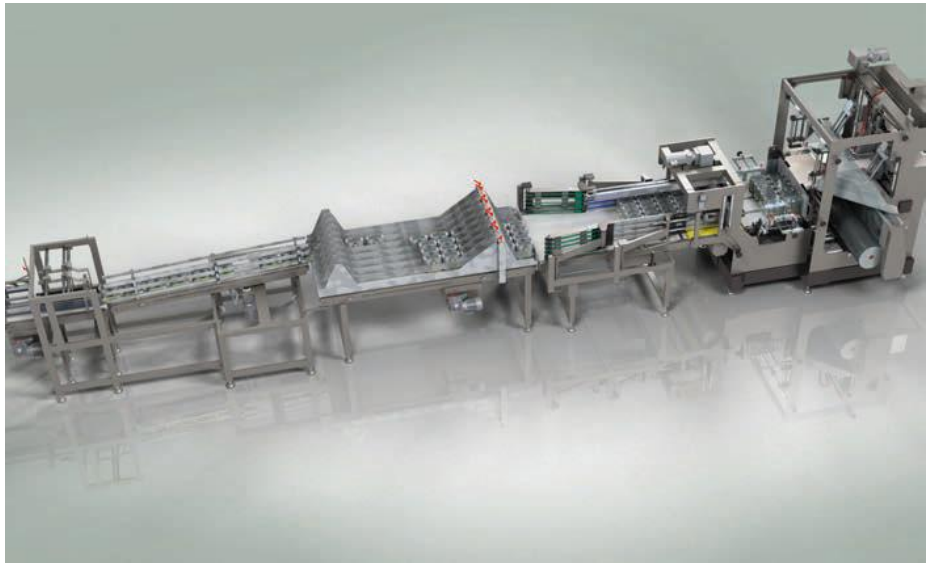
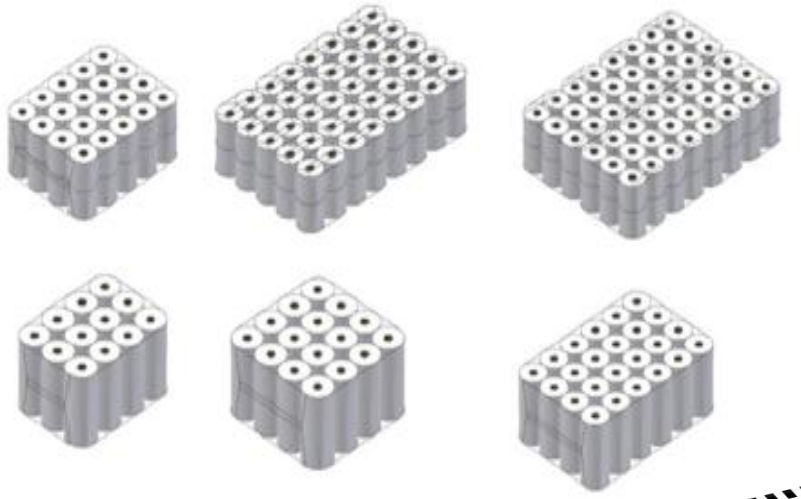
Rolls packs products bundler – Folded products case packer

Barcode group









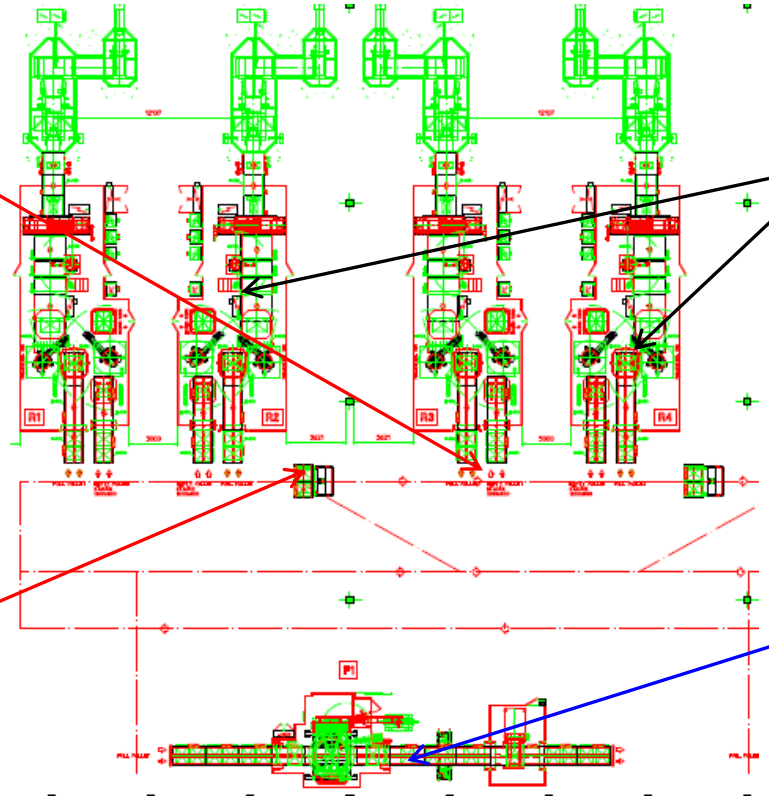
Folded products case packer

Complete rolls packaging line

enrico galli, 2016

Palletization, stretch wrapping and internal logistic

Finished products are shipped to customers warehouses and distribution centers on pallet (Logistic Unit – normally EUROPALLETS 80x120 cm) wrapped with stretch film: palletization and stretch wrapping are today performed by fully automatic plants using anthropomorphic robots, automatic [rotating table or arm] stretch wrappers and AGVs (more frequently LGVs).



For any question please feel free to contact me:

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Additional slides

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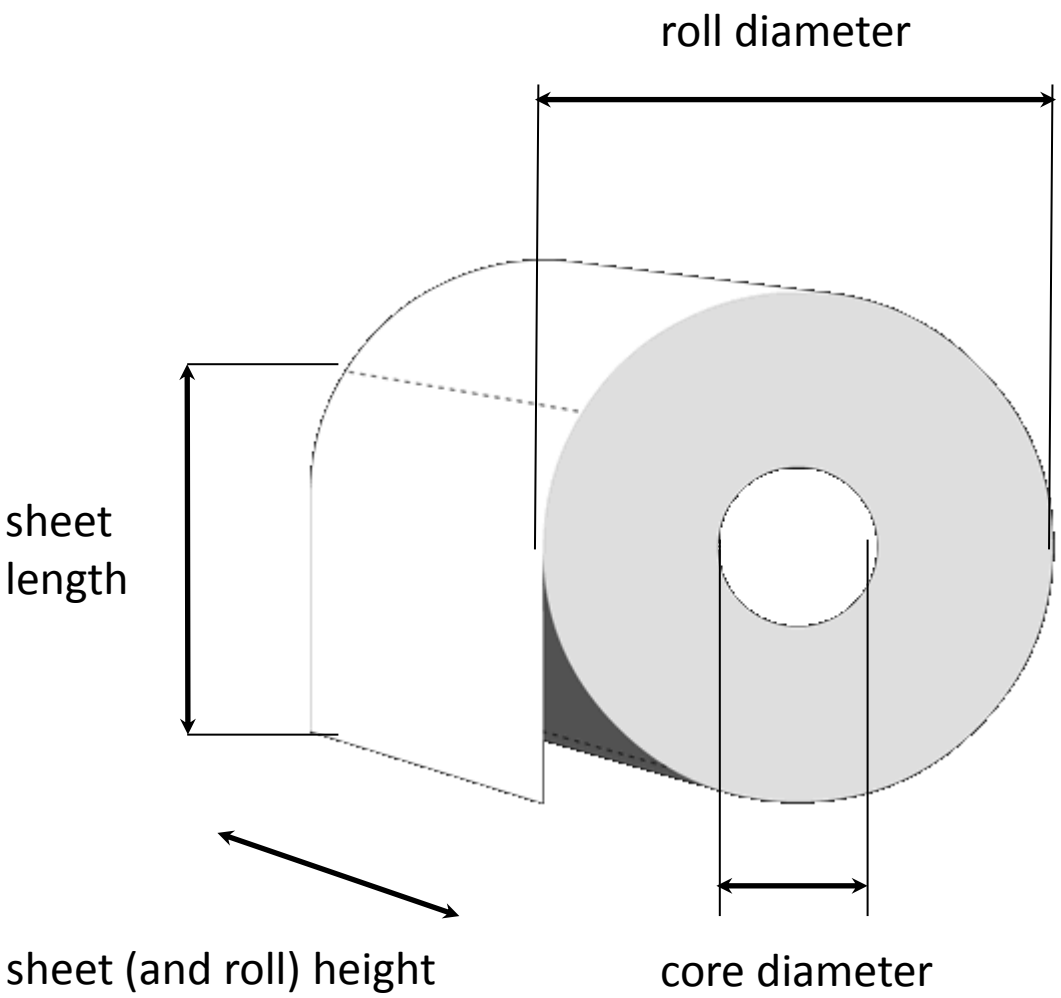
Toilet paper: colored or white?
…and what about decoration?

The toilet paper roll



- Sheet (and roll) height: 90-100 mm
- Sheet length: 122-138 mm
- Roll length = sheet length x number of sheets
- Roll diameter = 100-120 mm
- Core diameter: 38-50 mm

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Kitchen rolls: colored or white? Multicolor decoration. The "big" ones.

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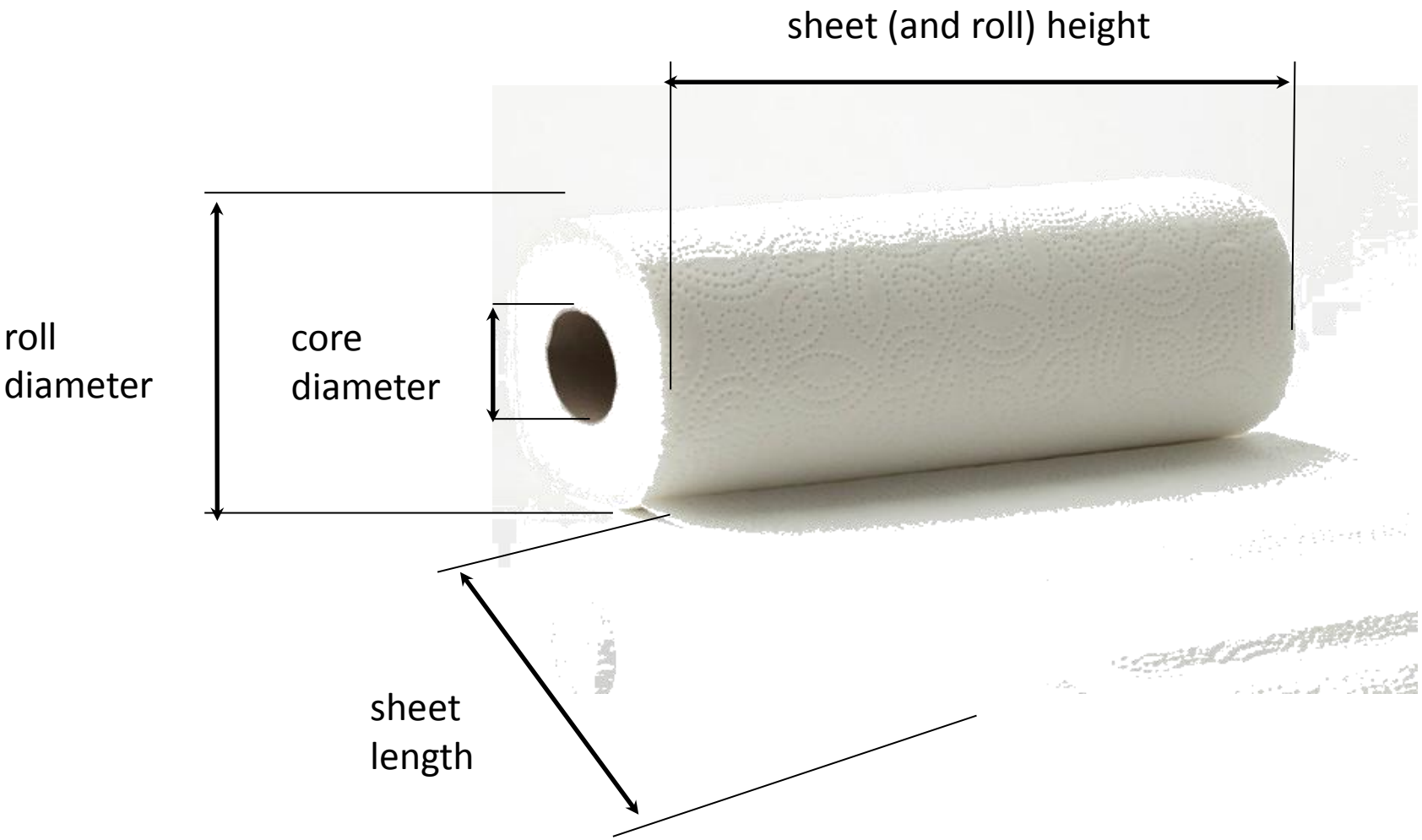
The kitchen roll



- Roll diameter = 100-120 mm (“big” ones up to 160 mm) - Core diameter: 38-50 mm
- Sheet (and roll) height: ~225 mm (rare up to 260 mm) - Sheet length: 210-240 mm
- Roll length = sheet length x number of sheets

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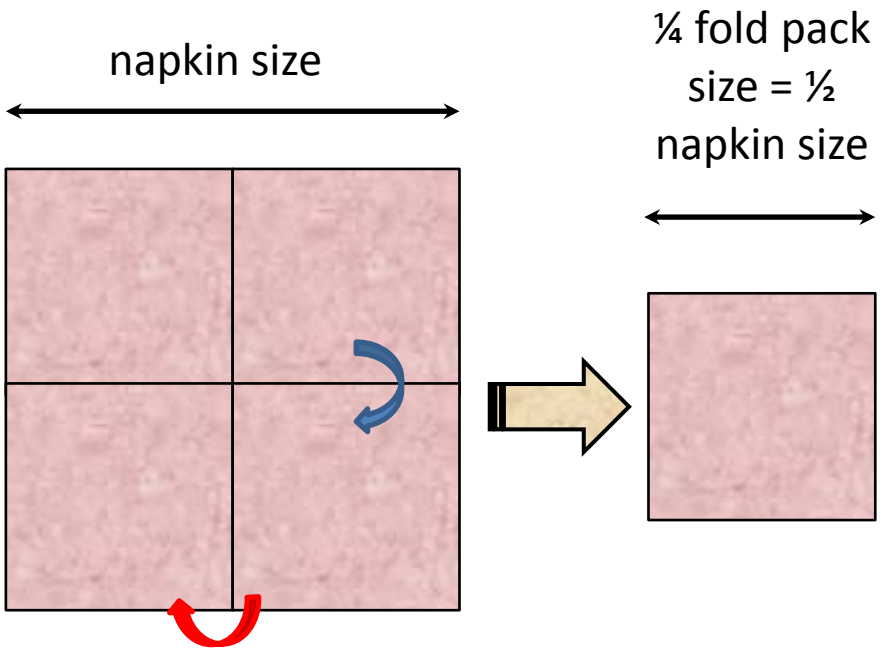
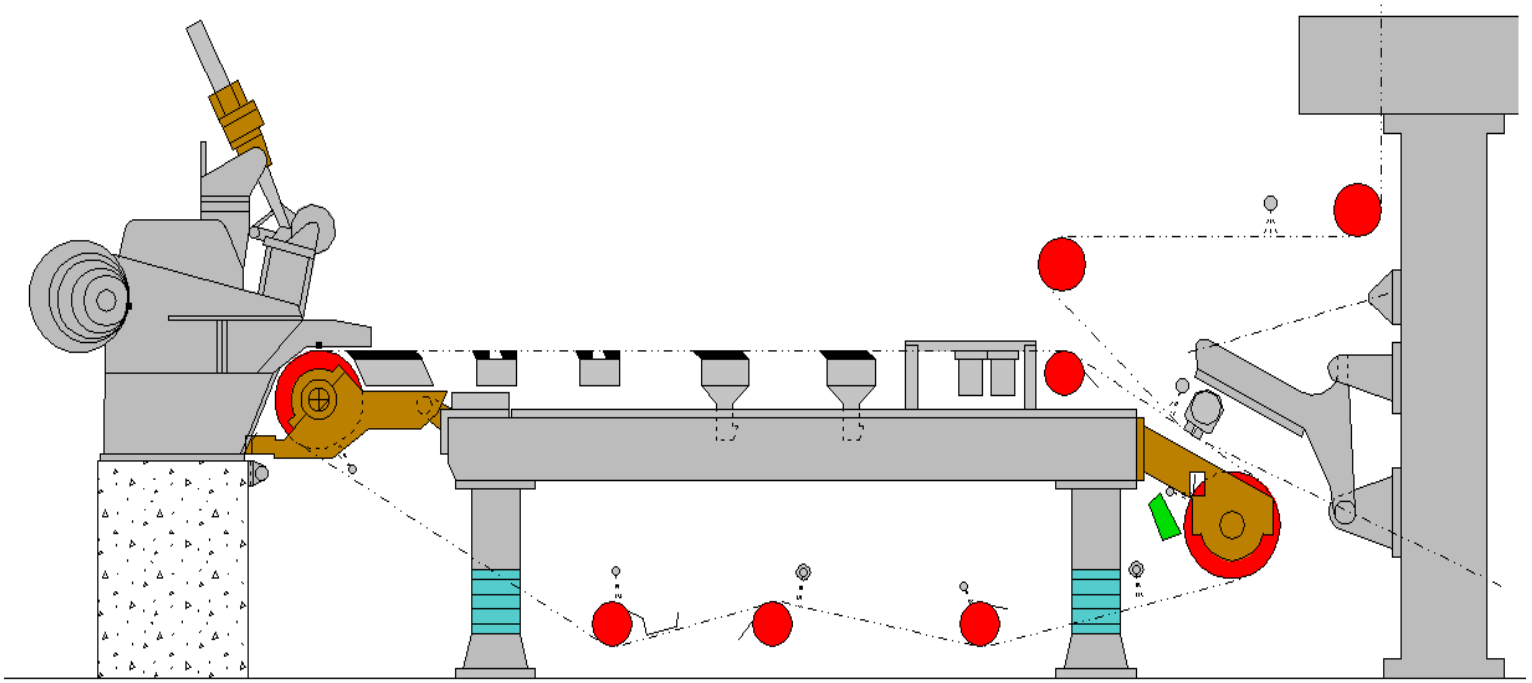
The napkins world



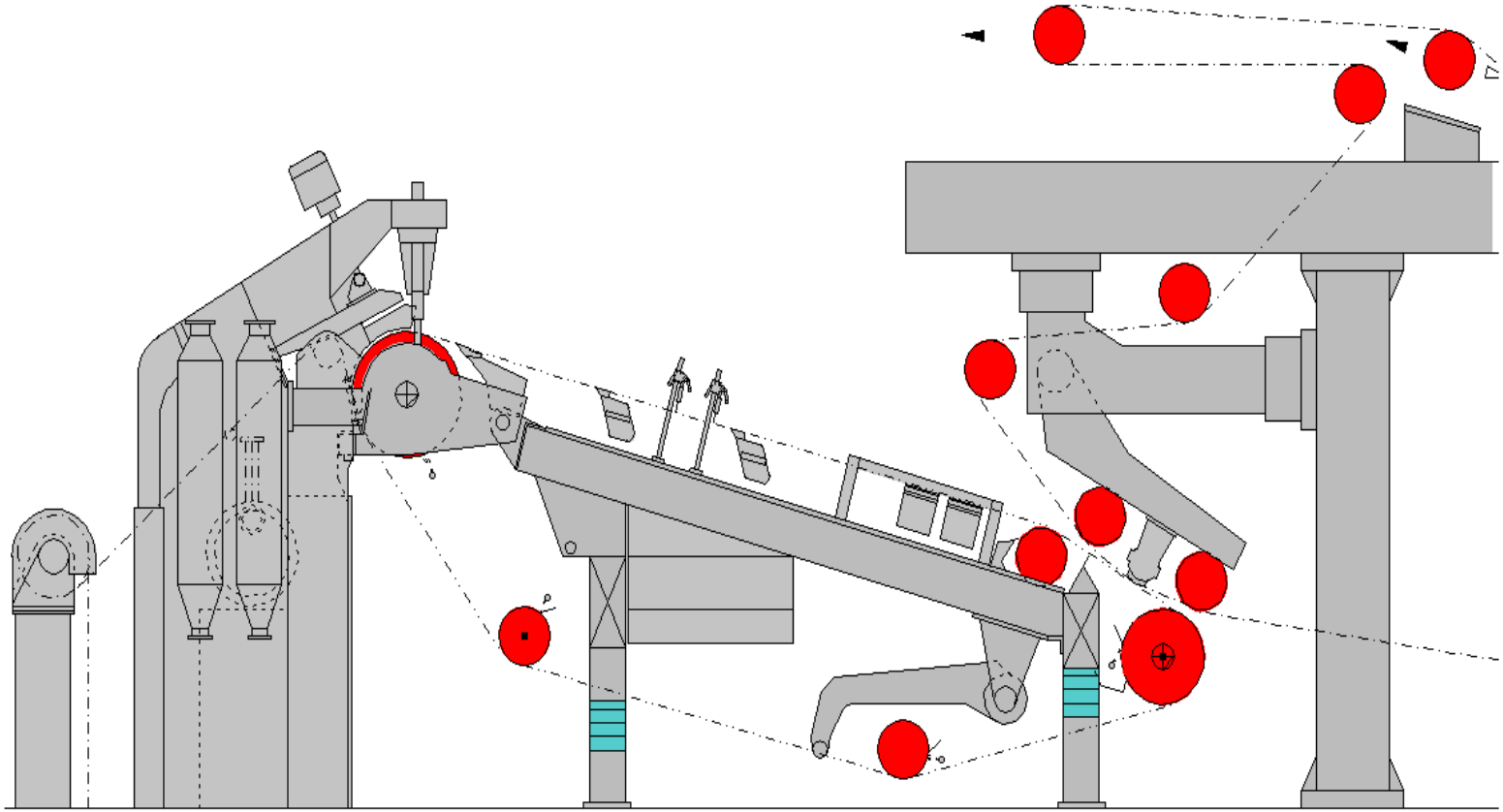
- Napkins common sizes: 24x24 cm – 30x30 cm – 33x33 cm – 38x38 cm – 40x40 cm
- In case of ¼ folded napkins the [single] pack sizes result: 12x12 cm – 15x15 cm – 16,5x16,5 cm – 19x19 cm – 20x20 cm

enrico galli, 2017

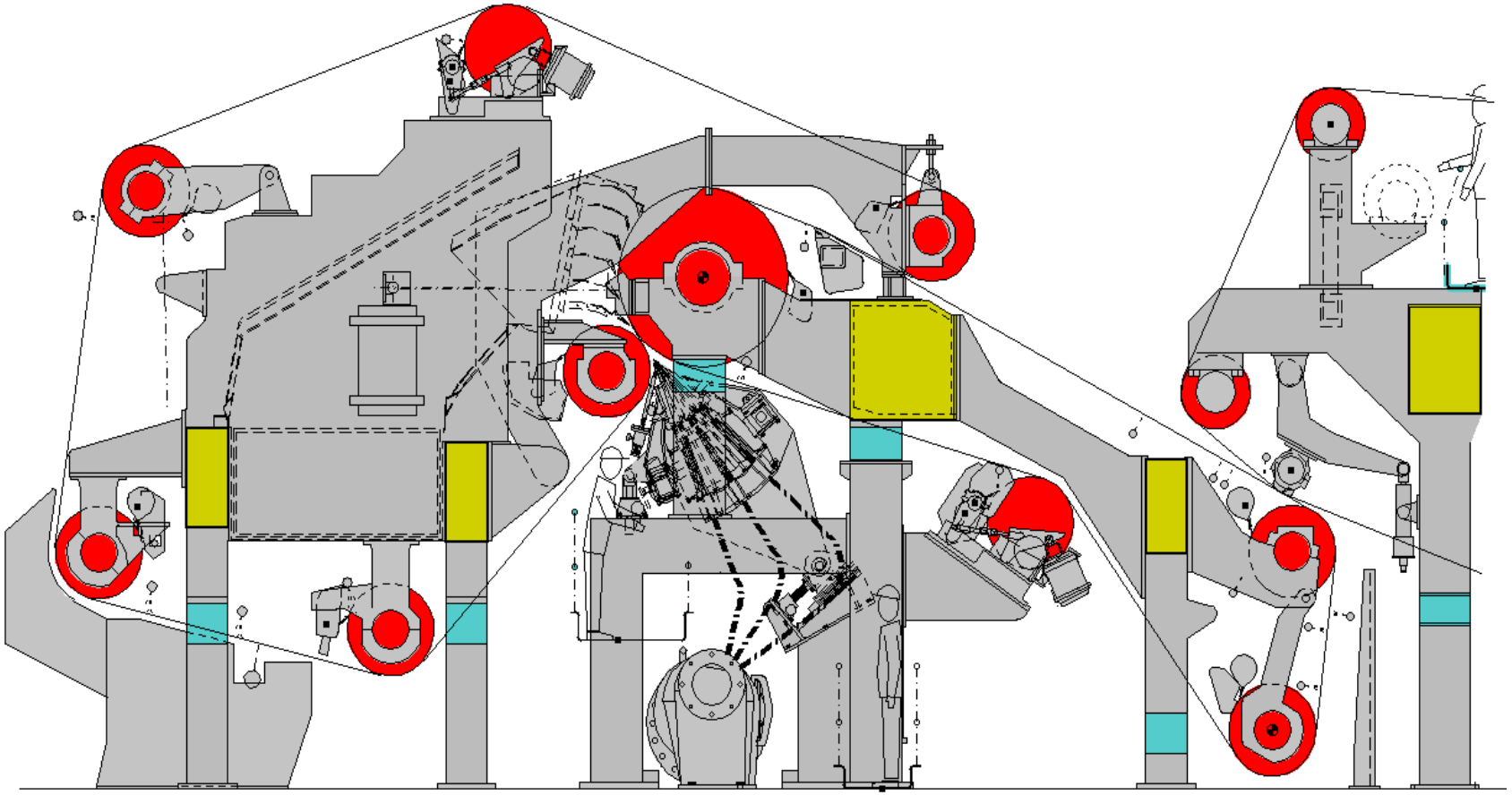
Fourdrinier with solid breast roll



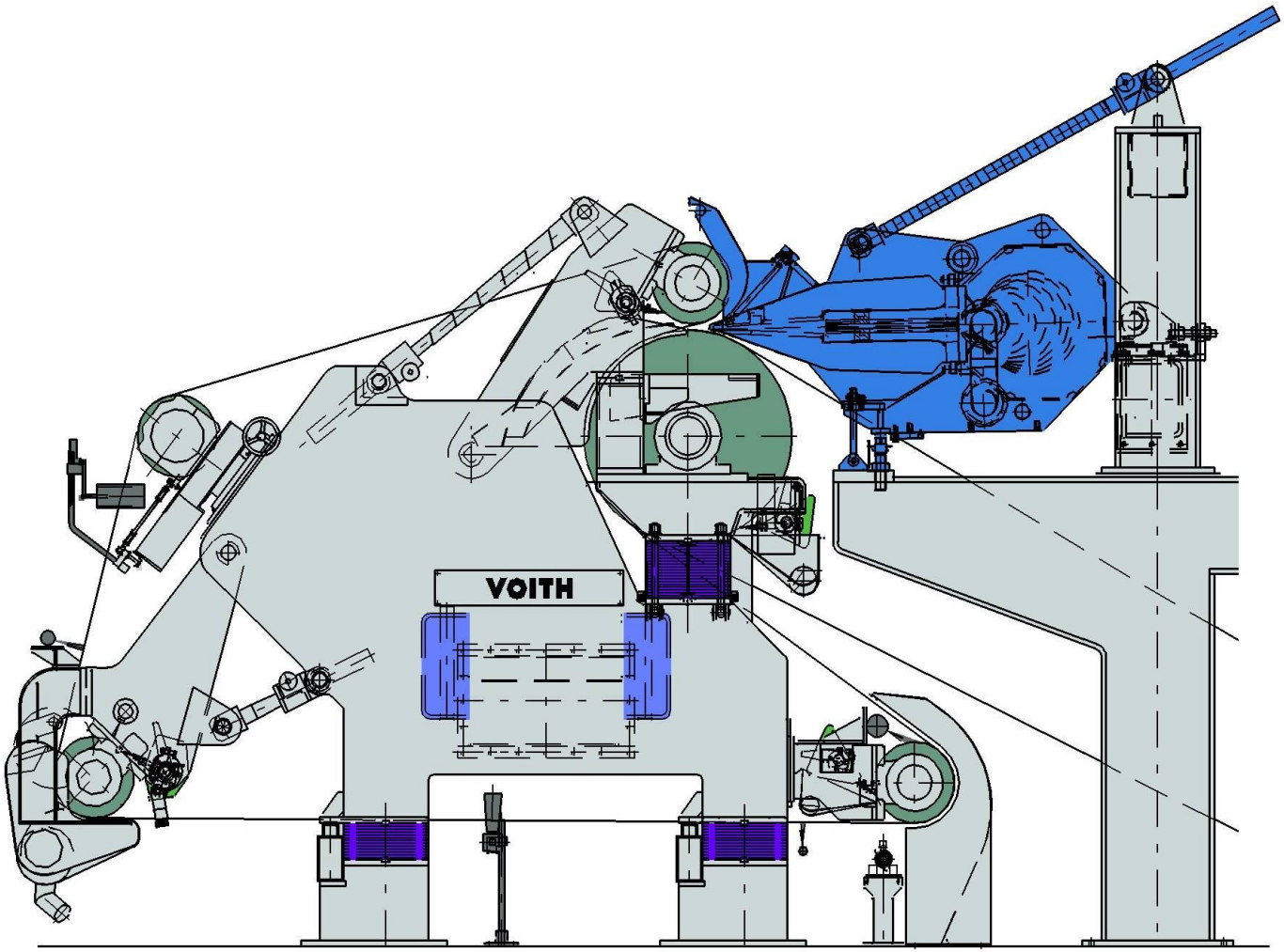
Inclined wire with suction breast roll



C Wrap Former



Crescent Former



Prova links

1	**Yankee Dryer Dry Creping Basics**	http://www.convergencetraining.com/yankee-dryer-dry-creping-basics.html
2	**Steam Theory for Tissue Machines**	http://www.convergencetraining.com/steam-theory-for-tissue-machines.html -> 6
5	**Yankee Dryer Coating**	http://www.convergencetraining.com/yankee-dryer-coating.html
6	**Yankee Dryer Design and Construction**	http://www.convergencetraining.com/yankee-dryer-design-and-construction.html -> 9
9	**Yankee Dryer Steam and Condensate Systems**	http://www.convergencetraining.com/yankee-dryer-steam-and-condensate-systems.html
10	**Yankee Hoods and Air Systems**	http://www.convergencetraining.com/yankee-hoods-and-air-systems.html