

On the way to the latest packaging R2R Metallizer

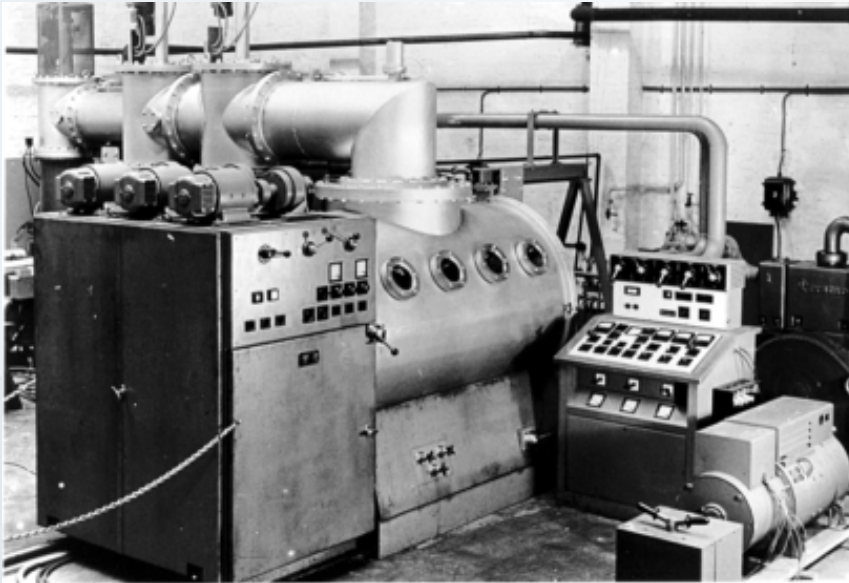


AIMCAL FALL Conference 2011

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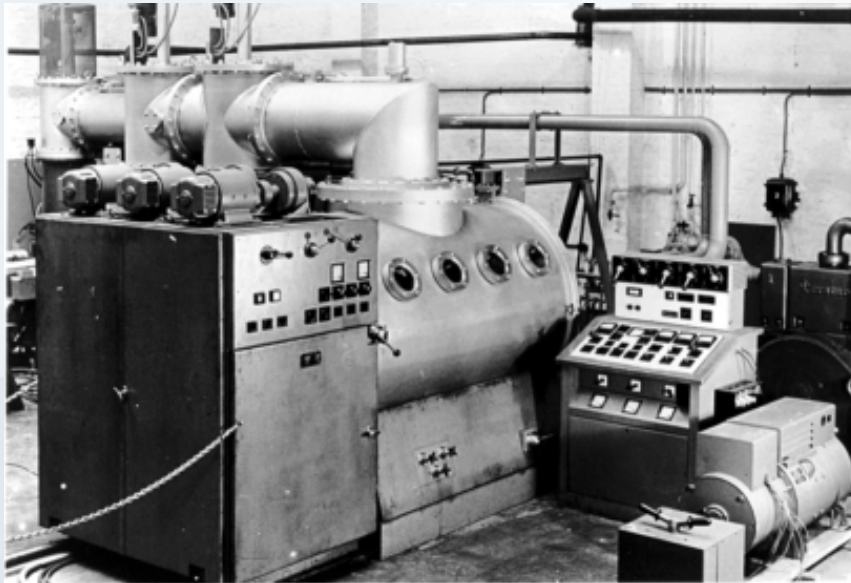
Outline



W.C. Heraeus R2R Coater build in 1952

1. Motivation
2. General requirements
3. Vacuum system
4. Sources, Pre- Post treatment
5. Winding
6. Operation / Roll handling
7. Quality control
8. Summary

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Motivation

R2R (Roll to Roll) High Vacuum Coating Systems for decorative packaging substrates are built and commercialized since the early 1950's. The need of R2R metallizers for the production of flexible packaging material has increased continuously in parallel with the growing demand of food packaging. The packaging industry has claimed over the years, a better utilization of raw material by down sizing the film thickness and cost efficient production AND, at the same time with stronger requirements for coating uniformity, defect-less and barrier properties, all to guaranty an extended shelf life of the packed food.

These changing conditions have forced the engineers of the machine manufacturers to consider more recent concepts and developments while keeping the Cost Of Ownership at reasonable numbers.

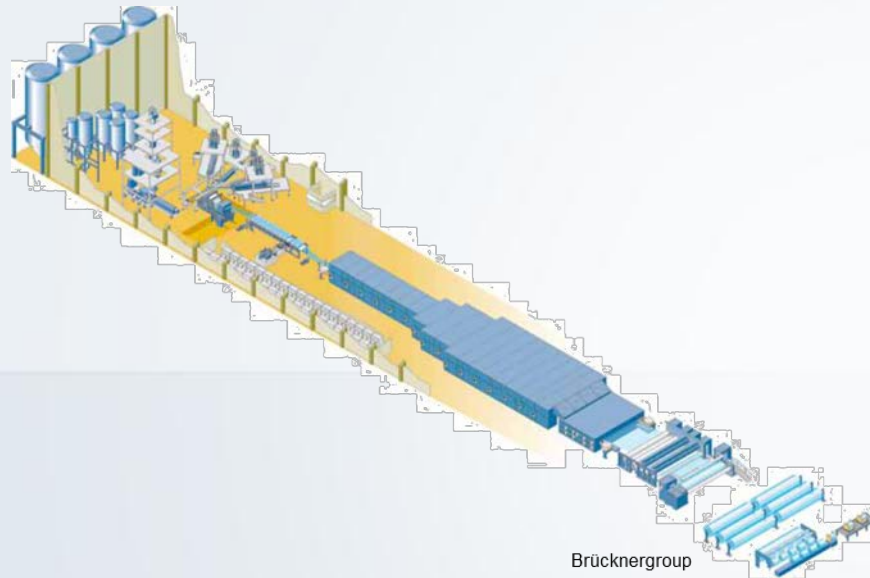
The design study from the scratch opens up many opportunities and the implementation of new ideas - all for the benefit of the equipment user.



Metallizer built by Applied Materials

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Base Parameter, to be considered



- Coating width: 1450 mm – 2850 mm
- The maximum coating width rises over the years due to the increasing Film-line sizes
- Roll diameter: Up to 1250 mm
- The maximal roll diameter, high productivity, depends on the process capability, run time of the coating source.

Base Parameter, to be considered

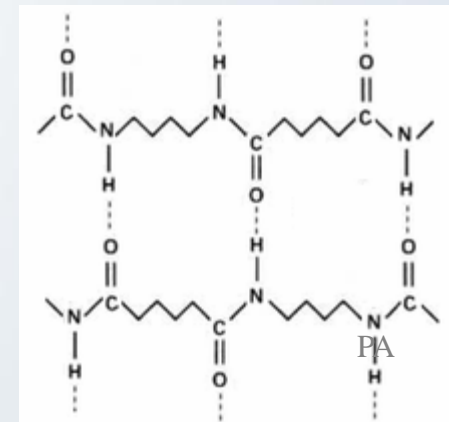
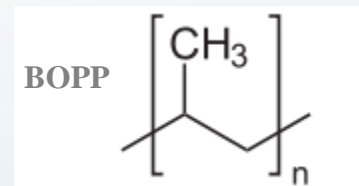
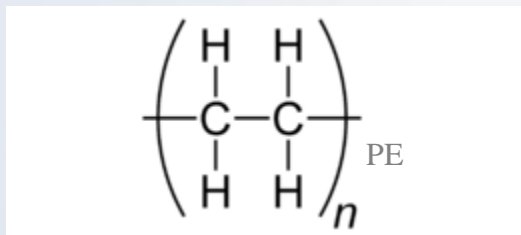
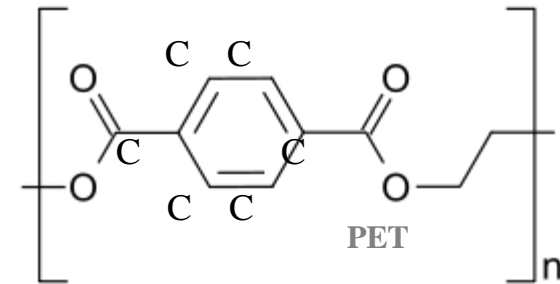
- Material line speed: Up to 20 m/sec, →high throughput
- Dimensions results out of substrate sizes and added subsystems
e.g. pre / post treatment app. 18500 x 4300 x 3000 mm (LxWxH)
- Energy-efficient operation
- Minimized water consumption
- Investment
- Ability to run multiple substrate materials and thicknesses



Leybold Heraeus Coater

Substrates

- Biaxially oriented PP film (BOPP)
- Cast polypropylene (CPP)
- High density polyethylene (HDPE)
- Low density polyethylene (LDPE)
- Polyamide (PA)
- Polyethylene terephthalate (PET)
- Polyvinyl chloride (PVC)
- Paper
- Others.....

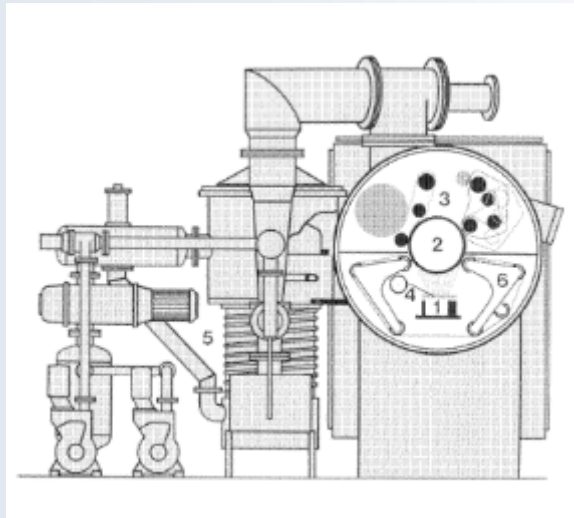


- Thickness varies from 12 μm to 70 μm

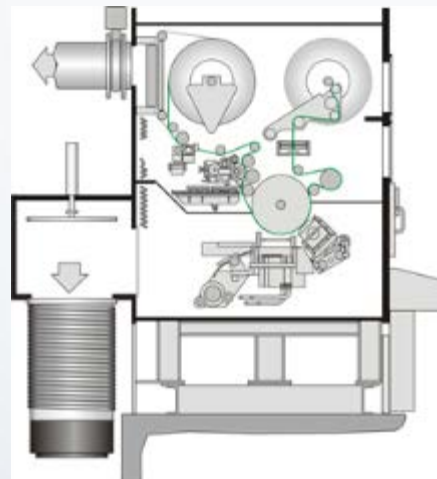
Chamber requirements

The vacuum chamber is the important part of the coater. It has to assimilate all components

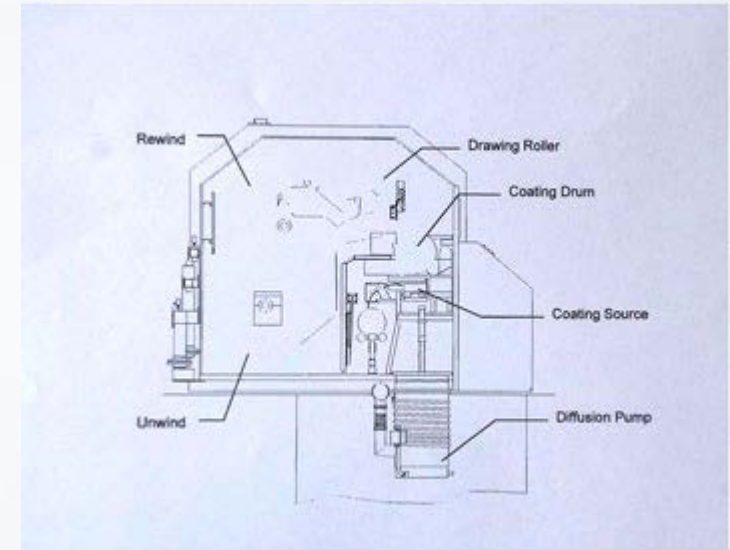
Its design requires high know-how according to the static calculation considering all feed through and view ports we need or may have in the coater.



1970 +



1990 +



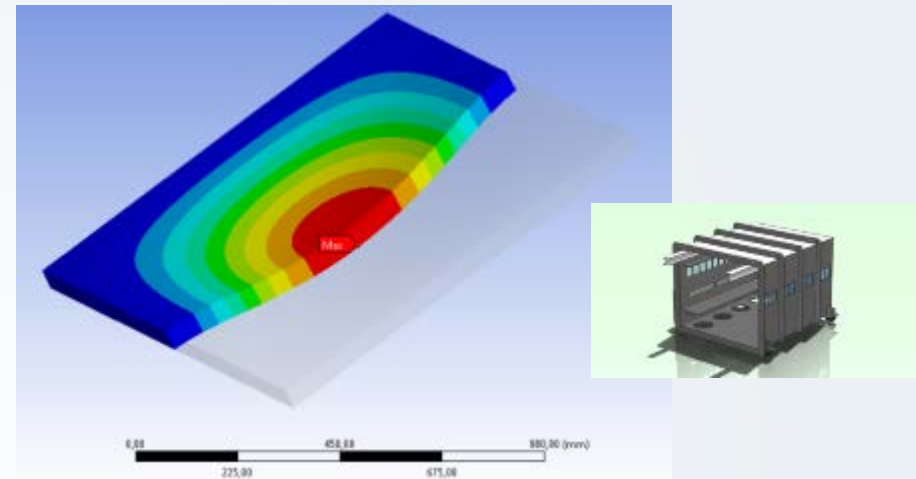
2000 +

Chamber designs and pump arrangement changes over the years due to the growing size of the coater.

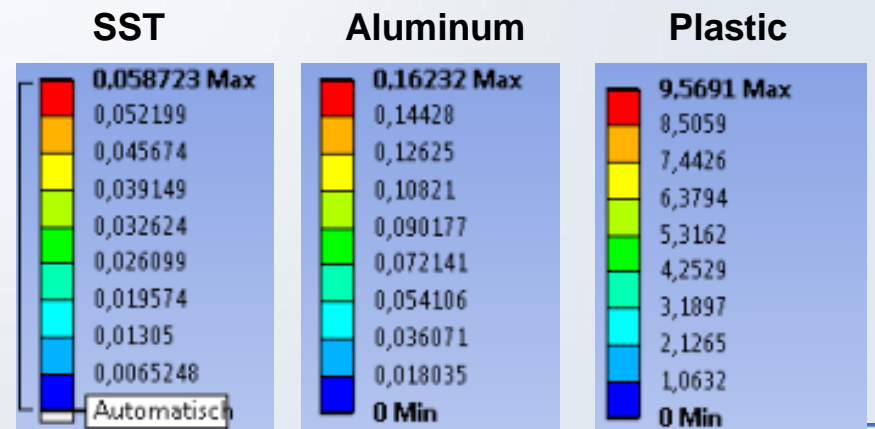
Where in the past the pump set requires more space than the chamber, it has completely changed till today.

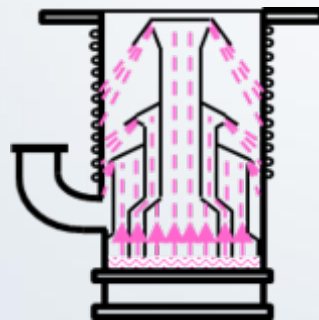
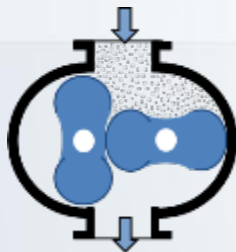
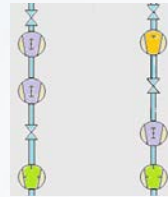
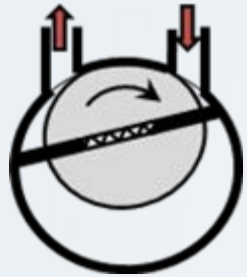
Chamber requirements

- Design Questions
- Volume → Vacuum → Winding Path
Static no bending
- Material? Plastic, SST, Al casted, painted?
- How many view ports do I need, and where?
- How is the access to Evaporator => two operator for fast boat change
- Flexibility, expandable for several width?
- Servicing and maintenance can be performed
- Are there known proven solutions like ...
- And what can be optimized?



The chart shows the bowing under load of a 1 m x 1 m x 50 mm plate, the bar diagram shows how much





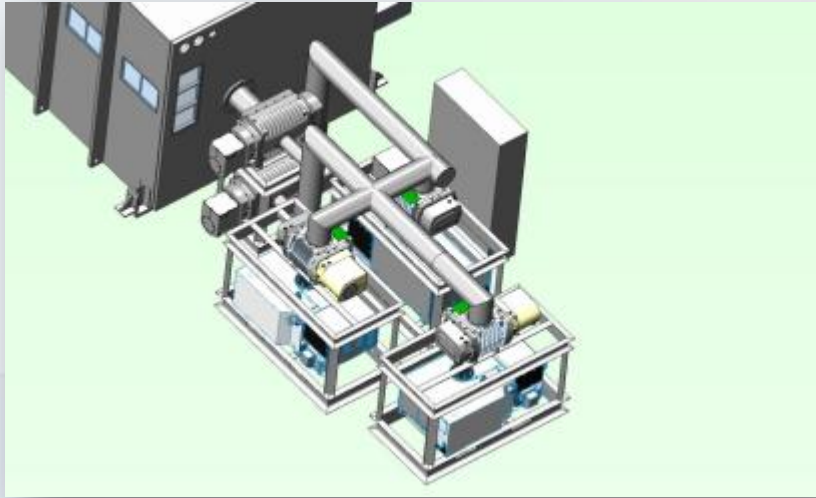
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Vacuum system

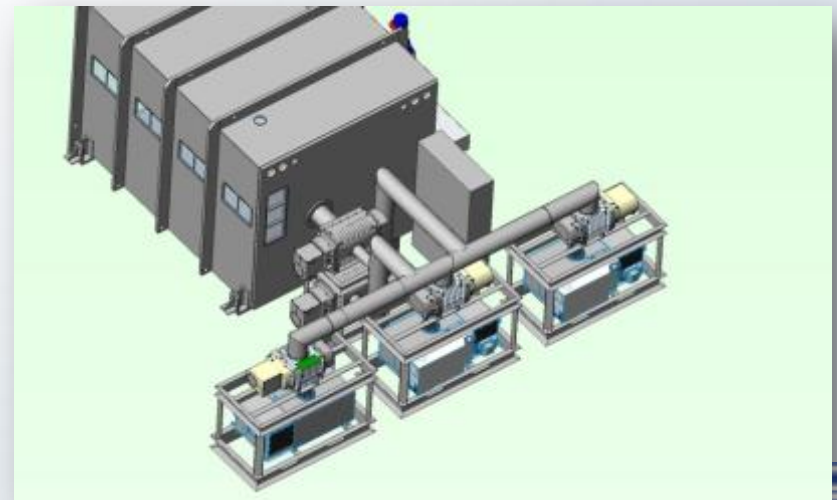
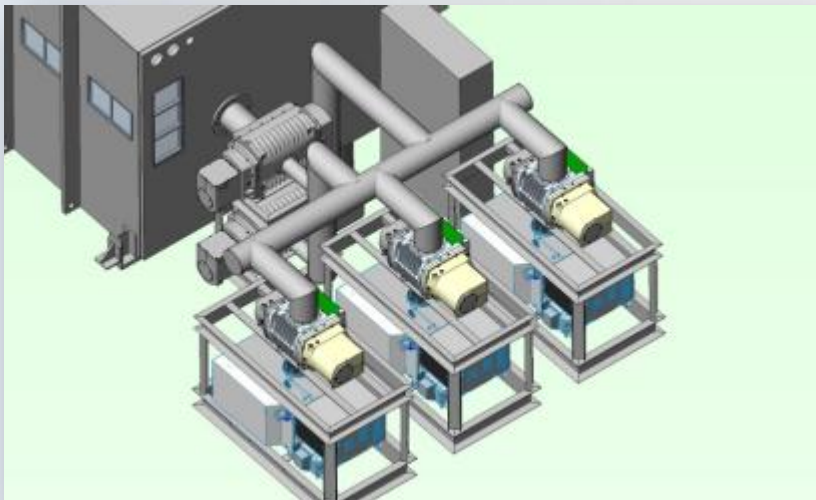


- Pump down time
 - Pumping capacity
 - Ultimate pressure
 - Venting time
 - Space
 - Flexibility
 - Energy consumption
 - Maintenance friendly
 - Cold trap surface
 - Additional pump set
 - Pump down time over the years
- | | | | |
|--------|--------|-------|---------|
| 1985 | 1990 | 2000 | 2010 |
| 20 min | 13 min | 6 min | < 6 min |

Flexibility of Vacuum pump set configuration



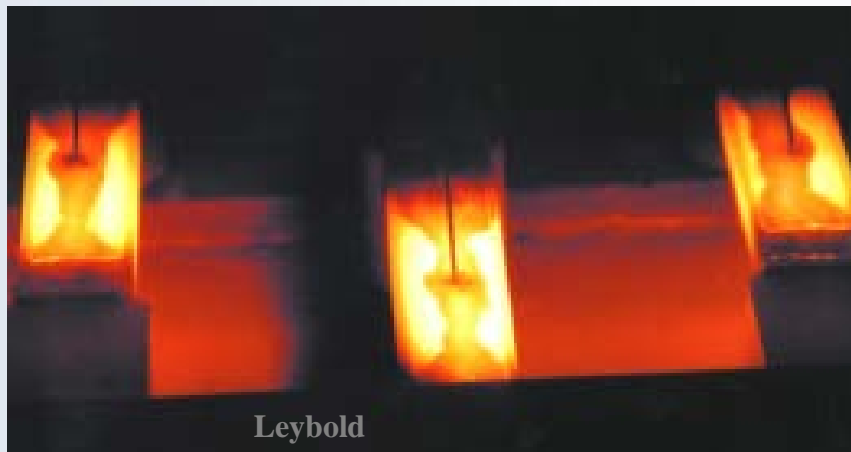
- **Flexible pre-pump set arrangement is required to fit to different customer facilities**





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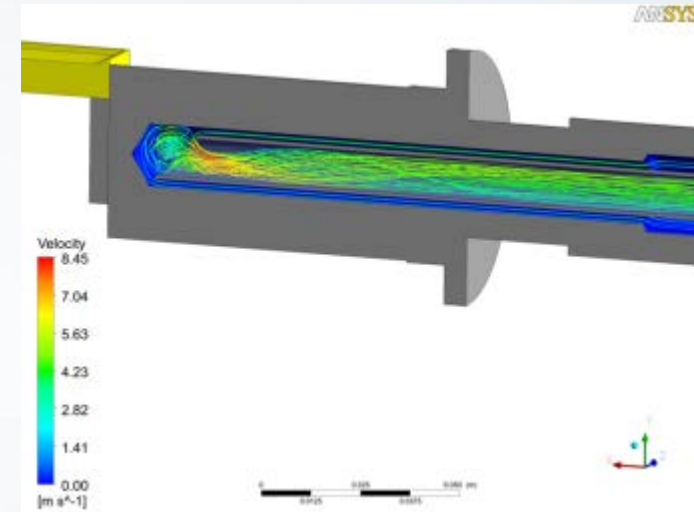
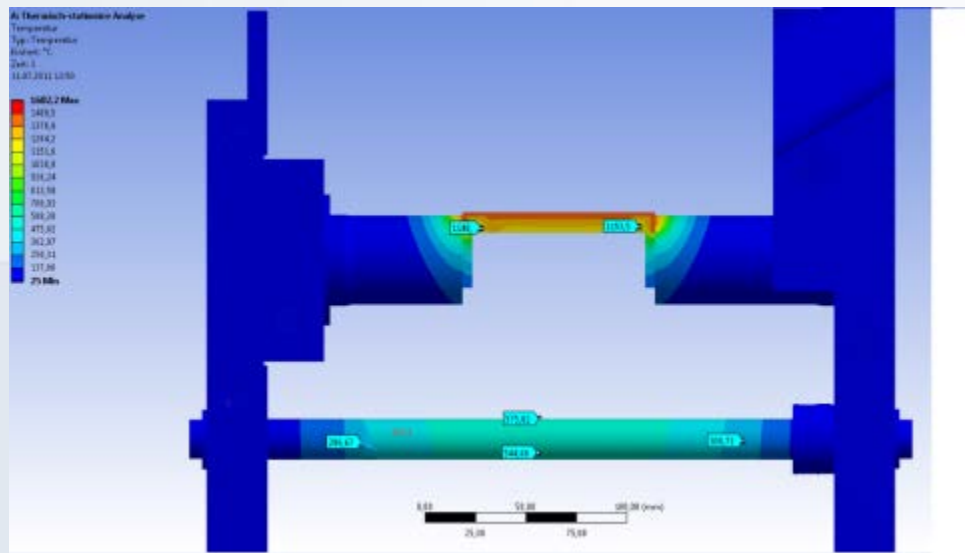
Sources



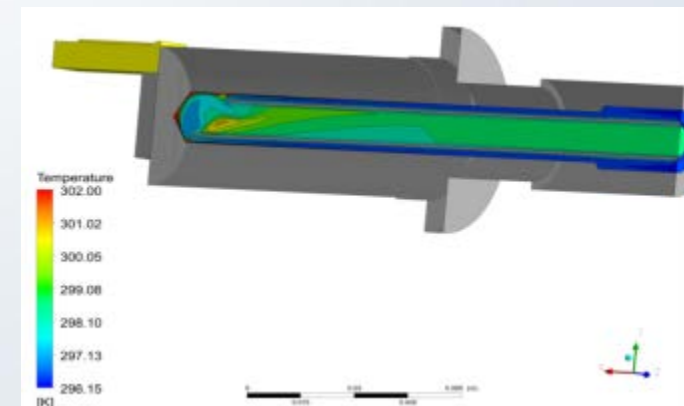
- Boat evaporator for:
- Al thick (barrier) 1.5 OD – 4 OD
- Al thin (anti static) app.0.5 OD
- Transparent barrier coating AlOx Ts ~ 90%
- Coating material:
- Al wire size 1.2 mm – 2.0 mm
- Aluminum coil diameter 280 mm - 360 mm
- The target is:
- High collection efficiency
- Excellent distribution
- No splashes, pinholes
- Long boat live time
- Less wall deposition
- Fast maintenance, clean ability
- We need:
- Precise al wire feed
- Staggered boat arrangement
- Energy-efficient operation using intelligent system control
- Easy access to all parts

Sources

The design starts with the contact bold

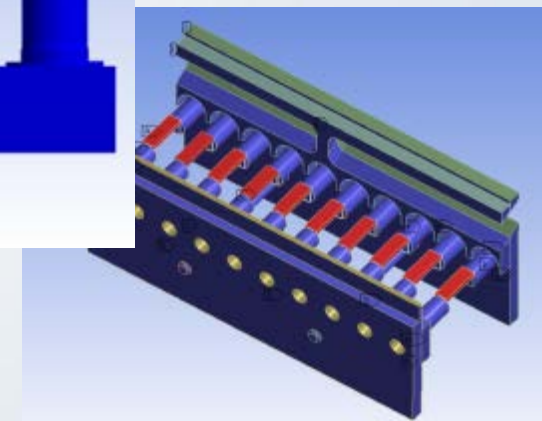
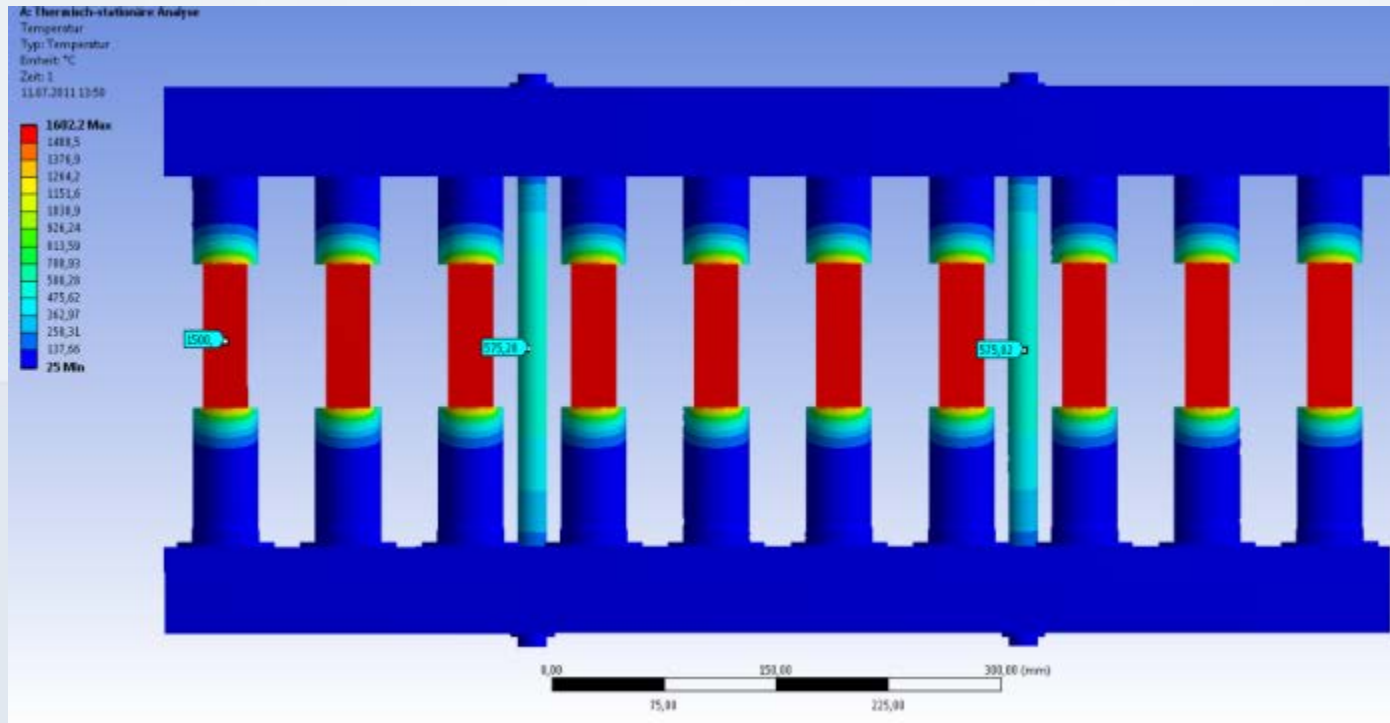


For the bold cooling the software simulation shows the fluid velocity and the resulting temperature distribution



- A software simulation is used showing the temperature distribution in the contact bold at working point for one boat
- Advanced software tools and its right use enables a further optimization of proved components

Sources

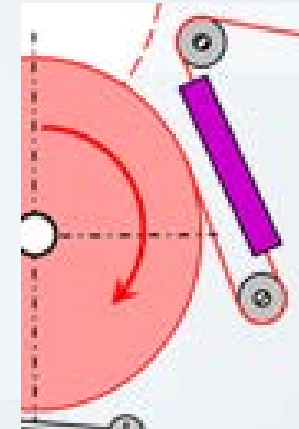


The final design of the complete evaporator box using the required numbers of boats.

Pre treatment

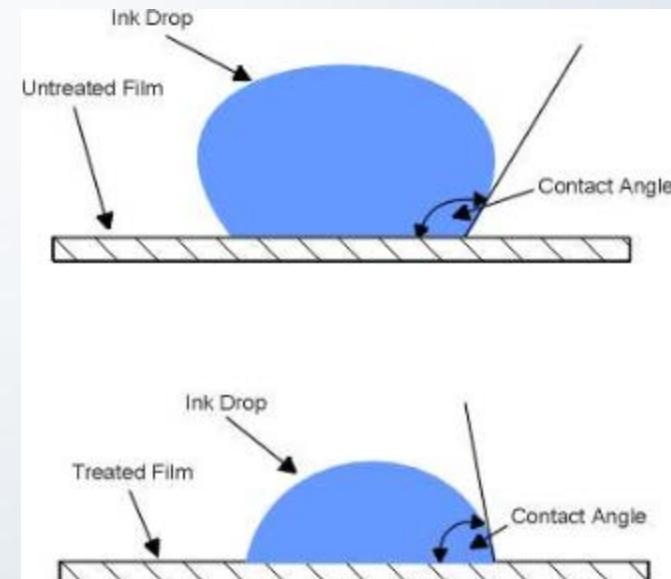
The pre treatment following on the web pass the unwinder is needed! To improve adhesion by strengthen the surface tension.

Via a low-pressure plasma adapting to the coating speed and film type. This results in better barrier properties.



Examples of surface tension:

	Untreated	treated
BOPP	38 dyn	44 dyn
PET	42 dyn	44 dyn



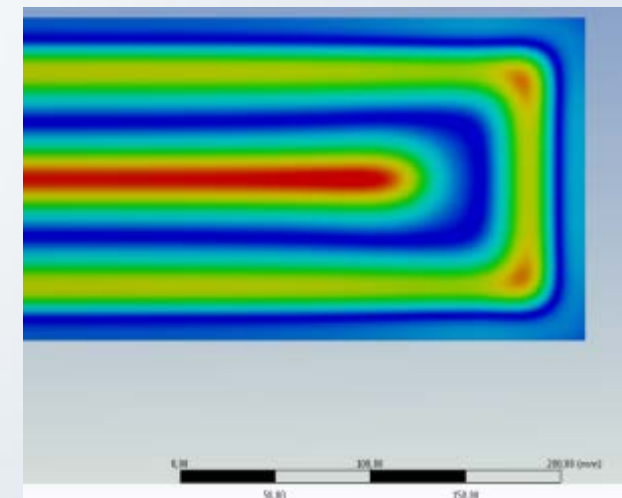
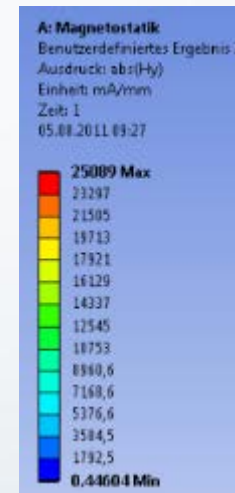
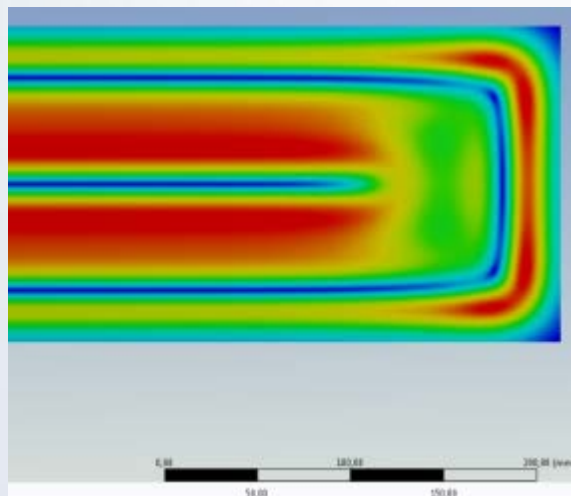
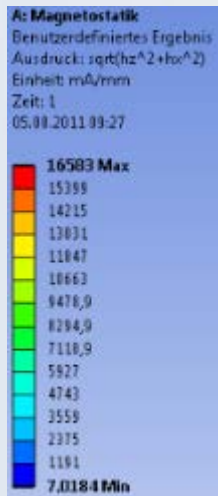
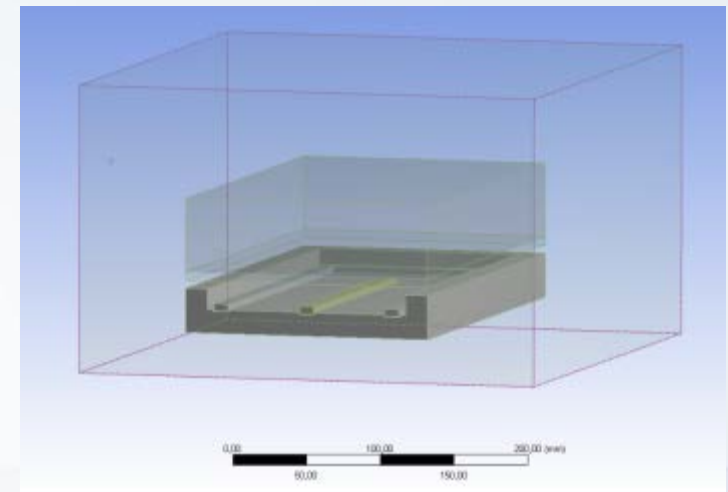
Source Brigham Young University

Pre / Post treatment

The needed low pressure plasma source has to fit to the treatment need of different foils BOPP or PET as well as to the maximum winding speed of the coater.

Power and gas flow needs to be adaptable to optimize the surface tension.

Typical used are planar magnet enhanced cathodes where the power type varies from DC, pulsed DC, MF or RF



The magnetic field strength shows the plasma concentration on the target surface versus different magnet file strength, the plasma width can be easily optimized.

Post treatment

Post treatment might not be always needed and can be an option.
The simplest form of post treatment is a post cool roller.



Leonhard Breitenbach GmbH

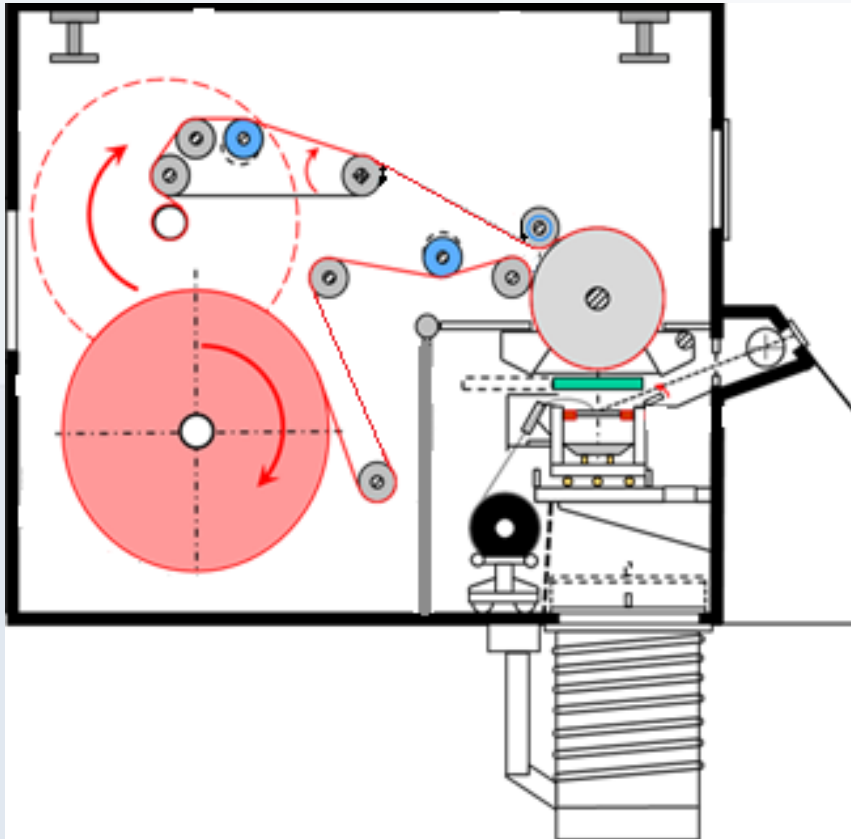


Further applications are post oxidation or layer stabilization
using a simple plasma.



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Winding



Cross section of a R2R coater showing the winding system.

- Design requirements:
- Use of standard components and parts
- Easy access to the roller
- Easy roll exchange
- Easy roll cleaning
- Robust
- Minimum needed number of roller

- Roller functions :

- Winding shafts
- Guiding roller
- Spreading roller
- Coating drum
- Measuring roller
- Tension roller
- Post cool roller

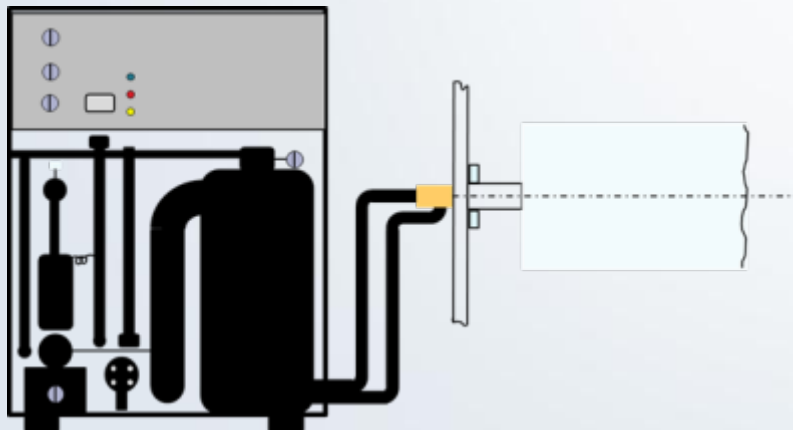
- Requirements are:

- Light weight
- Excellent concentricity

Winding



Van Baal Coating Drum



Sketch of a chiller coating drum connection

The coating drum is the most important roll of the winding system here we have to look at

- Bearings / feed trough
- Diameter
- Roll weight
- Tube design -> inertia of masses in movement
- Surface performance
- Defect avoidance (scratches, pin holes, pin windows)
- Homogen temperature distribution
-15 °C to 35°C +/- 2°C

Intelligent winding control via PLC for

- Precise web tension control 70 N to 700N



BOBST R2R coater

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Operation Requirements

HMI interface

- Easy
- Safe
- Operator friendly
- Maintenance friendly
- Self explaining user interface
- Clearly arranged overview

Full Automatic two button system

- Sequence:
 - Pump down
 - Evaporator on
 - AI wire start
 - Winding start
 - Shutter open
 - Layer control on
 - Stop at roll end
 - Venting



Further requirements

- Machine control
- Error management
- Winding control
- Safety interlocks

Roll handling



- Requirements
- Weight up to 5 tons per roll
- High risk to damage the winding system while loading
- Recommended is to use a full automatic loader for unload and reload controlled by a common interface of loader and coater.
- Fast but save



WC Heraeus Coater

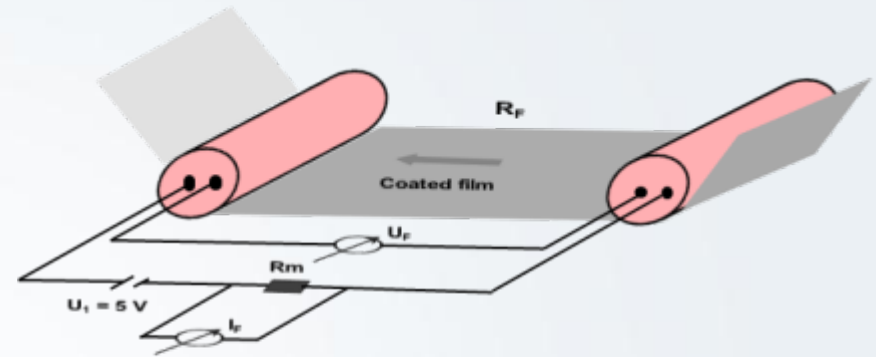
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Quality control

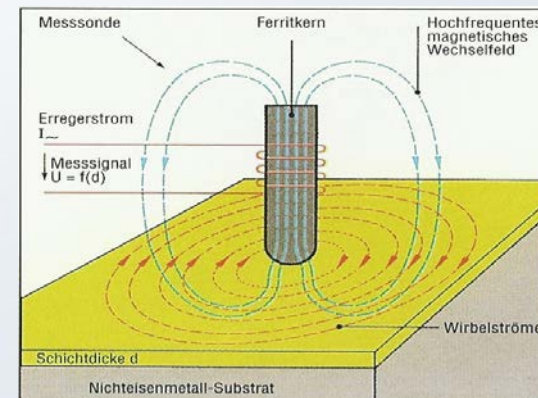
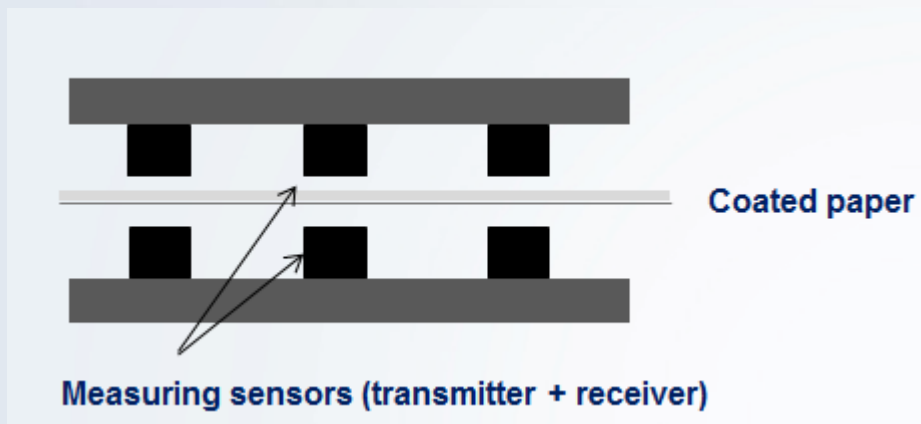
Electrical:

Roll to Roll sheet resistance measurement can be used for closed loop layer thickness control in web direction.

Eddy current sheet resistance measurement can be used for closed loop thickness control in web direction and transversal distribution control.



$$R_F = \frac{U_F}{I_F}$$



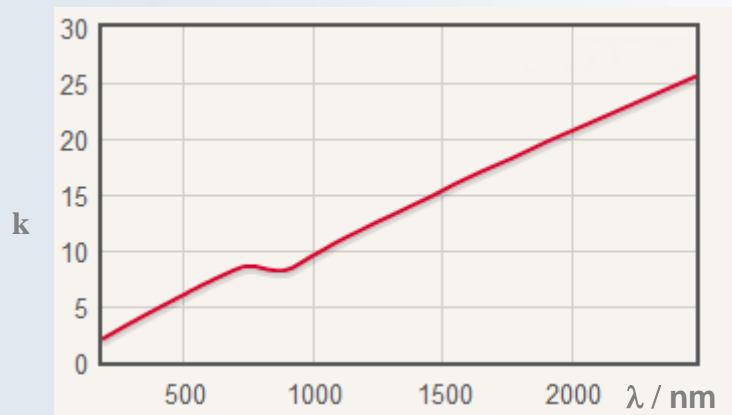
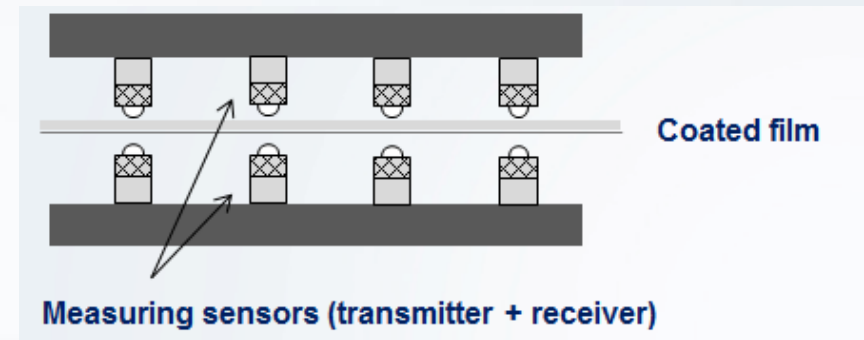
Source BAM

Quality control

Optical density measurement is used for quality monitoring via a roll report as well as for a closed loop thickness control for each single evaporator boat.

This results in good layer distribution.

The measuring wavelength is typical 860 nm



K – diagram of metal Al , non opaque
Source filmetrics

$$\Rightarrow d = \frac{-1 \times \ln (10^{-OD})}{4 \times \pi \times k / \lambda}$$

The equation shows the relation of optical density and layer thickness

What's not mentioned herein but still Important

- Electrical design
- Arrangement of cable and cabinets
- PLC control and visualization
- Cooling circuits and water manifold
- Chiller and cold trap (Meißner trap)
- Additional functions for trouble shooting
- Assemble and reassemble ability
- Packaging and transportability

- And more



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SUMMARY

- To get the latest state of a R2R coater we have to consider the interaction of all components
- The use of Computer Aided Engineering (CAE) enables the optimization of known used components
- By choosing the latest development of components combined with field proven components resulting in high quality design
- State of the art packaging roll to roll coater need to have insitu quality control

Thank you for your Attention!

