ASPECTS TO DEVELOP A R2R COATER

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Outline

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

W.C. Heraeus R2R Coater build in 1952
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W.C. Heraeus R2R Coater build in 1952
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.
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Metallizer built by Applied Materials
Substrate Parameter, to be considered

- Coating width: 1450 mm – 2850 mm
  - Fit to film lines width of 8,4 m to 10,4 m
- The maximum coating width grew over the years due to the increasing Film-line sizes
- Maximum Roll diameter 1250 mm
- The used roll diameter, depends on:
  - the process conditions (layer)
  - run time of the coating source
Further Parameter, to be considered

- Material line speed: Up to 20 m/sec, → high throughput
- Footprint is driven by:
  - substrate sizes
  - subsystems
- Energy efficiency
- Media consumption
- Investment
- Substrate range:
  - type
  - thicknesses
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.

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.

1970 +

1990 +

2000 +
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 operators 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 differences in materials:

- **SST**
  - 0.058723 Max
  - 0.052199
  - 0.045674
  - 0.039149
  - 0.032624
  - 0.026099
  - 0.019574
  - 0.01305
  - 0.0065248

- **Aluminum**
  - 0.16232 Max
  - 0.14428
  - 0.12625
  - 0.10821
  - 0.090177
  - 0.072141
  - 0.054106
  - 0.036071
  - 0.018035

- **Plastic**
  - 9.5691 Max
  - 8.5059
  - 7.4426
  - 6.3794
  - 5.3162
  - 4.2529
  - 3.1897
  - 2.1265
  - 1.0632
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Vacuum system

- Pump down time
- Pumping capacity
- Ultimate pressure
- Venting time
- Footprint
- Flexibility
- Energy consumption
- Noise level
- 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 1.5 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
Sources - The design starts with the contact bold

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

For the bold cooling the software simulation shows the fluid velocity and the resulting temperature distribution
Temperature distribution of the evaporator box
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:

<table>
<thead>
<tr>
<th></th>
<th>Untreaded</th>
<th>treaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOPP</td>
<td>38 dyn</td>
<td>44 dyn</td>
</tr>
<tr>
<td>PET</td>
<td>42 dyn</td>
<td>44 dyn</td>
</tr>
</tbody>
</table>

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.

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

- 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:
- Requirements are:
  - Winding shafts
  - Guiding roller
  - Spreading roller
  - Coating drum
  - Measuring roller
  - Tension roller
  - Post cool roller
  - Light weight
  - Excellent concentricity

Cross section of a R2R coater showing the winding system.
Winding

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
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Operation Requirements

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

Further requirements
- Machine control
- Error management
- Winding control
- Safety interlocks
- Reliable

Full Automatic two button system
- Sequence:
  - Pump down - Evaporator on - Al wire start - Winding start
  -> Shutter open - Layer control on - Stop at roll end - Venting
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
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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 currant sheet resistance measurement can be used for closed loop thickness control in web direction and transversal thickness control.

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.
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)
- Assemble and reassemble ability
- Needed viewports and spare flanges
- Additional functions for trouble shooting
- Packaging and transportability
- And more …….
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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!

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