On the way to the latest state of the art packaging R2R metallizer

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Abstract:

R2R (Roll to Roll) vacuum coating systems for packaging films are built since the early 1960's. The need of R2R metallizer has continuously increased with the growing demand for food packaging. The packaging industry claimed over the years, always thinner and less expensive packaging's together with stronger requirements for the barrier properties to extend the shelf life of the packed food.

While initially PET (polyethylene terephthalate) films, with thicknesses of 20 to 30 microns, are coated with a relative, non-uniform thick layer of aluminum, today different types of film such as PET, OPP, BOPP, CPP, paper etc. are being used. Thicknesses of the various substrates came from 6 microns to 20 microns and are coated with different barrier layers such as aluminum or aluminum oxide. The early substrate widths were between 0.6 m to 1.2 m.

Over the years the film producers were able to produce wider substrates with increased productivity. In parallel, the R2R system manufacturers had to follow the trend by enlarging their machines in widths and an increased line speed. From the early days, production speed has raised from 6 – 10 and later to 14 m/sec.

Now the plants became wider, from originally 0.6 m width up to 3 m coating width. The biggest R2R coater at present shows 4450 mm metallized film width, what fits to the half of an extruded jumbo roll of app. 9000 mm wide. These continue changing conditions forces the engineers to develop more recent concepts and developments which have to be cost efficient at the same time.

The presentation describes the modeling, analysis and decision making process to design a new coater, based on the recent customer and market requirements, with the knowledge of the existing technology and the necessary "Know How" to the latest generation of R2R packaging metallizer systems for the food packaging market.

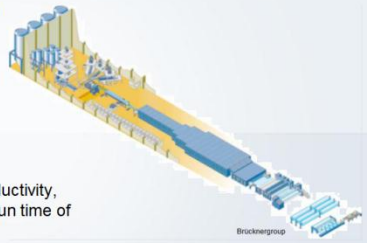
Discussed is the decision-making during the new design study of the system components for which are always the development steps of the previous generations are considered. Further discussed in the presentation are the current customer requirements for production optimization.

The current market requirements for substrate width, flexibility, vacuum system, coating sources, plant operation, role handling, quality control, service and ease of repair are discussed and quantified.

A final summary presents the results.

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.



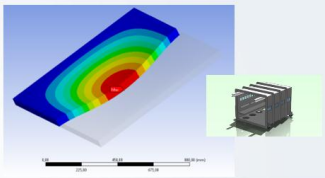
Base Parameter, to be considered

- 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

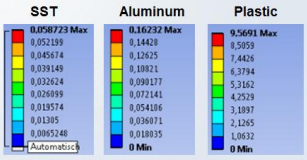
Chamber requirements

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



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

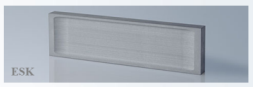
Sources

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

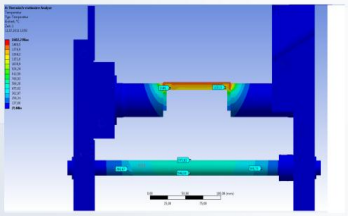
The target is:
- High collection efficiency
- Excellent distribution
- No splashes, pinholes
- Long boat live time
- Less wall deposition
- Fast maintenance, clean ability

We need:
- Precise al wire feed
- Staggered boat arrangement
- Energy-efficient operation using intelligent system control
- Easy access to all parts

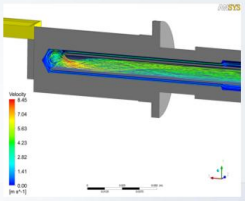


Sources

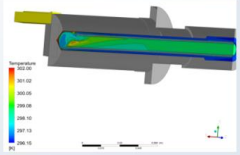
The design starts with the contact bold



- 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



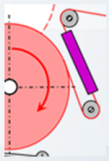
For the bold cooling the software simulation shows the fluid velocity and the resulting temperature distribution



Pre treatment

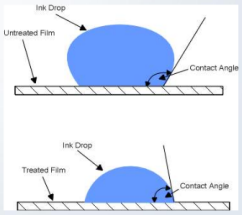
The pre treatment following on the web pass the unwinder is needed! To improve adhesion by strengthen the surface tension.

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



Examples of surface tension:

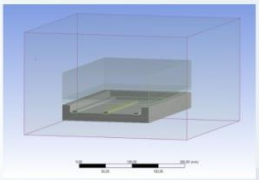
	Untreaded	treaded
BOPP	38 dyn	44 dyn
PET	42 dyn	44 dyn

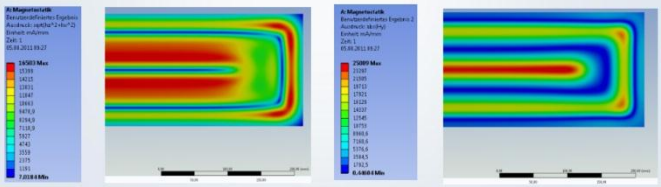


Source Brigham Young University

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





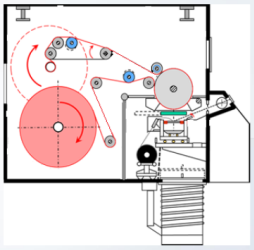
The magnetic field strength shows the plasma concentration on the target surface versus different magnet file strength, the plasma width can be easily optimized.

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

Requirements are:
- Light weight
- Excellent concentricity



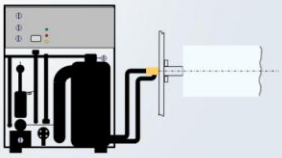
Cross section of a R2R coater showing the winding system.

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

Van Baal Coating Drum

Intelligent winding control via PLC for
- Precise web tension control 70 N to 700 N



Sketch of a chiller coating drum connection

Operation Requirements

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

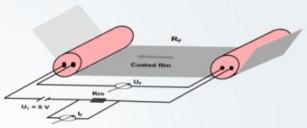
Full Automatic two button system
- Sequence:
  - Pump down
  - Evaporator on
  - Al wire start
  - Winding start
  - Shutter open
  - Layer control on
  - Stop at roll end
  - Venting

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

Quality control

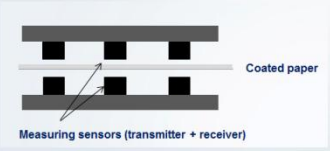
Electrical:

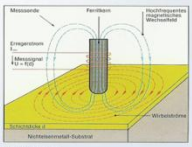
Roll to Roll sheet resistance measurement can be used for closed loop layer thickness control in web direction.



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

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



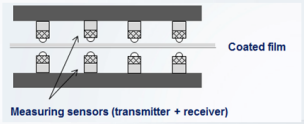


Source BAM

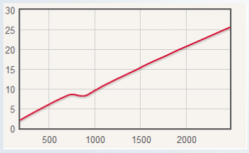
Quality control

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 value of Aluminum versus wave length
Source Filmetrics

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

The equation shows the relation of optical density and layer thickness

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