Metallizer Performance Evaluations

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EMMOUNT Technologies
Performance Evaluations

• Goal is to increase productivity and insure product properties
• Gain control of:
  – Incoming film
  – Machine settings and operation
  – Metallized film properties
  – Yield of product
Incoming Film Control

- Incoming roll properties
  - Gauge uniformity
  - Roll density
  - Storage conditions (control out gassing)
  - Formulation selection for metallizer

- Film Testing for Uniformity
  - Roll appearance
  - Roll density
  - COF
  - Treatment Level & Location
  - Film strength (material & Thickness)
Poor Quality Input Roll

Gauge uniformity problem

Poor wind of input roll

Poor slitting, edge quality
Additive Formulation Impact on Film

- Rail Road Tracks
- Film Blushing
- Contamination and Static tracks
Process Monitoring and Control

• Characterize performance of equipment
  – Cycle time / productivity
  – Product yield

• Control chart critical parameters
  – Process parameters
  – Product properties

• Experimental Performance evaluations
  – Designed Experiments for optimization
Machine settings and operation

- Chamber open time
- Time to metallization pressure
- Starting vacuum level
- Unwind / breaking tension
- Line speed
- Film cooling temperature
  - Metallization zone
  - Post metallization

- Wire Speed
- Optical density
  - Average
  - Point to point
- Final vacuum level
- Rewinding tension
- Final roll temperature
  - Metallized film
Process Charting of A Metallizer

New Boats  Change Operator

- Wire Feed Rate
- Line Speed

Roll Number

- Wire Feed Rate
- Line speed
Performance Evaluation Using Designed Experiments

- Determine product performance
- Characterize a process
  - Trouble shoot a process
- Improve the transfer of information
  - Create compact descriptions of the information
  - Quantification of errors
- Improve efficiency of experimentation
Metallizer Quality Measures

- “Appearance”
- Optical density level & variability
- Metal adhesion
- Gas & Moisture Barrier
- Surface resistivity
- Roll conformation
- Metal pickoff

Operating Parameters of Metallizers

- Unwinding speed
- Web tracking and tension control
- Vacuum level
- Evaporation control
  - Boat temperature (voltage & current)
  - Wire feed rate
- Web cooling
- Rewinding speed
Principle Metallization Variables

- **Independent variables**
  - Vacuum level
  - Optical density
  - Film Formulation
    - treatment level
    - COF technology
  - Web cooling conditions
  - Tension levels
  - Boat conditions
  - Mechanical condition & Cleanliness of rolls

- **Dependent variables**
  - Appearance
  - Optical uniformity
  - Metal adhesion
  - Barrier properties
  - Web speed
  - Exit roll temperature (pick off)
For New Product or Metallizer

• Screening experiment
  – Determine most significant variables
• Fractional factorial
  – Main effects and interactions
  – Linearity
• Surface Response Experiment
  – Higher order effects
• Optimization experiments
  – signal to noise ratio
## Box-Behnken Experiment

<table>
<thead>
<tr>
<th>Treatment combination</th>
<th>Vacuum</th>
<th>Roll Temperature</th>
<th>Optical Density</th>
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Measure dependent variables

- Oxygen permeability
- Optical Density Variation (number of peaks)
- Metal Pick off
  - 610 tape
  - 600 tape
- Final roll Temperature
- Contact angle
## Curve Fit Results to Experiment Model

- \( Y=a_0+a_1X_1+a_2X_2+a_3X_3+a_4X_1X_2+a_5X_1X_3+a_6X_2X_3+a_7X_1^2+a_8X_2^2+a_9X_3^2 \)
  - \( X_1=\)Vacuum Pressure \( 10^{-5} \) to \( 10^{-3} \)
  - \( X_2=\)Roll Temperature \(-15 \degree C\) to \(+15 \degree C\)
  - \( X_3=\)Optical Density \(1.5\) to \(3.0\)

<table>
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<tr>
<th>Property</th>
<th>½[MIN(_{90})]</th>
<th>Mean</th>
<th>P</th>
<th>T</th>
<th>OD</th>
<th>P*T</th>
<th>P*OD</th>
<th>T*O</th>
<th>P(^2)</th>
<th>T(^2)</th>
<th>OD(^2)</th>
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Demonstrates

• Importance of chamber pressure on properties
  – Starting pressure level
  – Time to starting vacuum
• Counter intuitive impact of chill roll temperature
  – Hotter can be better
• Interactions between Process variables common
• Some tests do not differentiate property
  – 610 vs. 600 tape
Utilization of results

• Set limit on pressure for metallization
  – Insure barrier properties
  – Improve optical density uniformity

• Implement maintenance schedule based on process
  – Time to start pressure

• Establish optimum process conditions
  – Chill roll temperature

• Establish tests to differentiate performance
Conclusions

• Process monitoring / control charting important
• Process studies and optimization experiments can be used to improve:
  – operating performance
  – Insure film properties
  – Minimize property variation
• Should be conducted:
  – on all production machines
  – For each base sheet / product type
Thank You

Questions & Comments