2009 Flexible Packaging Summit
Consumer Packaging Solutions for Barrier Performance Course

Blown Film Processes and Troubleshooting
The Ultimate Quality Control Tool

Presented by:
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President
Plastics Touchpoint Group, Inc.

Blown Film Properties

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Bubble in the Real World

- Air escaping from bubble from non-uniform closure of nip rollers
- Collapsing Frames not concentric too tight on one side
- Air currents on this side from open door or window
- Unstable bubble diameter
- Air ring not adjusted correctly
Reading the Signs

1. Look at the finished roll
2. Follow the web path backwards to identify causes of defects
3. Be patient…some changes take longer than others

Wrinkle Patterns

MD Wrinkles
- Fixed position

TD Wrinkles
- Repeating patterns
- Transient patterns
- Edge patterns

MD Wrinkles

Compression in the Transverse Direction

Bulge crossing roller
Wrinkles oriented in MD
Crease
Troughs

Max. roller deflection < 0.015% of roller width
Causes of Common MD Wrinkle Patterns

**Raw Material**
- Viscosity variation (port line affect)
- Water absorption (causes expansion of web)

**Processing Conditions**
- TD gauge variation
- Insufficient web tension between idler rollers

**Equipment**
- Insufficient traction on idler rollers
- Bent idler rollers
- Idler roller bearing not rotating properly

Film Tension Bands

May be caused by
- Too much film tension
- MD gauge bands
- Too much drag resistance from idler rollers

Locking Rollers Causes Problems
BGE Traversanip®

Wrinkles occur when air turning bar pressure is too high

“Tin Canning”

Solutions for Tin Canning

<table>
<thead>
<tr>
<th>Material</th>
<th>• Improve mixing inside die</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Increase modulus (density) of film</td>
</tr>
<tr>
<td></td>
<td>• Increase film gauge</td>
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<tr>
<td>Process</td>
<td>• Reduce film tension</td>
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<tr>
<td></td>
<td>• Reduce film temperature</td>
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<td></td>
<td>• Eliminate affect of air currents</td>
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<tr>
<td>Equipment</td>
<td>• Reduce drag resistance in collapsing frame</td>
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<td></td>
<td>• Reduce drag resistance in bubble cage</td>
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<tr>
<td></td>
<td>• Match rotation speed of rollers to line speed</td>
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<td></td>
<td>• Reduce width of spreader roller grooves</td>
</tr>
<tr>
<td></td>
<td>• Adjust position of spreader roller</td>
</tr>
<tr>
<td></td>
<td>• Reduce idler roller deflection</td>
</tr>
<tr>
<td></td>
<td>• Reduce drag resistance across idler rollers</td>
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</tbody>
</table>
Optimizing Collapsing Angle Side View

- Nip Rollers
- Angle
- Wrinkles
- Bubble

Wrinkles form if Angle is too large

Causes of Common Diagonal Wrinkle Patterns

Raw Material
- viscosity variation (melt channelling)

Processing Conditions
- Uneven web tension across the web
- Uneven drag resistance in collapsing frame

Equipment
- insufficient traction on idler rollers
- bent idler rollers
- idler roller bearing not rotating properly

Tension and Elastic Modulus

- Slack film can cause wrinkles when entering nip rollers
- Wrinkles point toward region of lower tension

Too Tight
- Amount of force (stress) that plastic can withstand and still return to its original dimensions
- Winding tension must never exceed this value

Too Loose
Spiral Wrinkle Pattern

- Web Pattern
- Roll Pattern

Calculating Film Tension with Air Loaded Dancer

\[
Tension = \frac{\text{Total Pressure} - \text{Pressure to raise dancer}}{\text{Gauge} \times \text{Width} \times \text{Layers}}
\]

- Total Pressure = pressure reading on gauge (Kg, psig)
- Pressure to raise dancer = pressure to make dancer float (Kg, psig)
- Gauge = film gauge (microns, mils)
- Width = width of film (mm, inches)
- Layers = 1 for sheeting, 2 for tubing

Starred or Spoked Rolls
Starred or Spoked Roll Deformation Mechanism

Pressure from outside layers compresses inner layers

Roll deforms into star or spoked pattern because layers buckle when compression is too high

Solutions for Starred or Spoked Rolls

Material
- Reduce density difference between layers (co-ex)
- Change layer ratio to avoid curling (co-ex)

Process
- Adjust melt temp. to bring frost lines closer together (co-ex)
- Reduce film temperature
- Reduce film tension at winder
- Reduce lay-on pressure at winder

Equipment
- Improve winding tension control (watch movement of dancers)

Affect of Tapered Gauge Variation

Left side 460mm / 18” diameter

Right side 430mm / 17” diameter

Camber will cause film to track off center in converting equipment.
Roller Misalignment Patterns

- Wrinkles appear to walk uphill
- Wrinkles reach downstream roller and point toward narrow side
- Slack edge (low tension) with no wrinkles

- Web tension
- Tension
- Gauge
- Web span
- Line speed
- Traction

Wrinkles appear to walk uphill
- Tension
- Web span
- Gauge
- Line speed
- Traction

Flat Film Wrinkles

Misalignment Angle

Slack Edge (no wrinkles)

Wrinkles reach downstream roller and point toward narrow side

Slack edge (low tension) with no wrinkles

Bubble Misalignment

Bubble touches cage
- Bubble does not touch cage

Moves with oscillating nip?
- Yes    Realign collapsing frame and side stabilizers
- No     Problem caused below collapsing frame
Evidence of Misaligned Collapsing Frame

![Graph showing evidence of misaligned collapsing frame](image)

Tapered Rolls

![Diagram of tapered rolls](image)

Solutions for Tapered Rolls

**Process**
- Reduce melt temperature variation (melt channeling)
- Eliminate air drafts across bubble

**Equipment**
- Align die
- Align air ring
- Align cage
- Align collapsing frame
- Align haul-off nip
Affect of Transfer Pipes on Flow Profiles

Heater Band
Flange
Exit from Screen Changer
Downstream Clamping Ring

Melt Channeling
Side Opposite Extruder is Hotter

Melt Flow at Exit from Elbow
Melt Flow at Entrance to Elbow

Affect of Melt Channeling

“Sow Belly” Hot side becomes thinner before freezing.
Extruder Side
Air Ring
Single Peak TD Gauge Variation

Collapsing Frame

Linear Plot

Processing Conditions
- Uneven melt flow inside die (melt channeling)
- Hot air rising from extruder or other air currents inside the factory

Equipment
- Die lip not centered
- Air ring or IBC stack not centered
- Tilted die, air ring or IBC stack

Polar Plot

Ringed Rolls

Solutions for Ringed Rolls

<table>
<thead>
<tr>
<th>Material</th>
<th>Process</th>
<th>Equipment</th>
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<tbody>
<tr>
<td></td>
<td>• Reduce film COF (add slip)</td>
<td>• Repair worn haul-off nips (slippage)</td>
</tr>
<tr>
<td></td>
<td>• Keep film tension between 1% and 25% of ultimate tensile strength</td>
<td>• Realign die, idlers, cage, collapsing frame</td>
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<tr>
<td></td>
<td>• Eliminate web tension pulsations</td>
<td>• Replace dull slitting blades</td>
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<td></td>
<td></td>
<td>• Clean dirty rollers</td>
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</table>
**Edge Variation**

- **Sawtooth**
  - slippage in nip
  - tension variation at slitters

- **Oscillation from side to side**
  - misaligned die, cage, collapsing frame

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**Gauge Variation at Die Lips**

1 M8 LDPE in HDPE Die at 200°C (395°F) Melt Temperature
6 Ports, 6 Port Overlap, 2 mm (80 mils) Die Gap, 200 kg/hr (485 lb/hr)

Flow Rate Simulation:
- Flow2000
- Capacitance Type Gauge Profiler
  - Automatic Calibration Option
  - Capacitance Sensor
  - Nip Rollers

---
Fourier Analysis

Look for causes of cycles that do not fit on the curve

Before Air Ring Adjustment

Target: 0.750 mils
Average: 0.752 mils
Range: +23% / -25%
Std Dev: 7.2%

After Air Ring Adjustment

Target: 0.750 mils
Average: 0.776 mils
Range: +29% / -59%
Std Dev: 21%
Affect of Misaligned Air Ring

<table>
<thead>
<tr>
<th>Die Position</th>
<th>Gauge Profile</th>
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<tbody>
<tr>
<td>A</td>
<td>41.9 μ / 1.65 mls</td>
</tr>
<tr>
<td>B</td>
<td>40.4 μ / 1.59 mls</td>
</tr>
<tr>
<td>C</td>
<td>38.9 μ / 1.53 mls</td>
</tr>
<tr>
<td>D</td>
<td>38.4 μ / 1.51 mls</td>
</tr>
</tbody>
</table>

Note gap between air ring and bubble

Affect of Tilted Air Ring

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<tr>
<th>Die Position</th>
<th>Gauge Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40.1 μ / 1.58 mls</td>
</tr>
<tr>
<td>B</td>
<td>40.4 μ / 1.59 mls</td>
</tr>
<tr>
<td>C</td>
<td>38.1 μ / 1.50 mls</td>
</tr>
<tr>
<td>D</td>
<td>38.6 μ / 1.56 mls</td>
</tr>
</tbody>
</table>

Note gap between air ring and bubble

Key Air Ring Adjustments

- Velocity CONTROLS
- Volume COOLS
Air Ring Control Points
Single and Dual Lip Air Rings

Single Lip

Dual Lip Iris

Dual Lip Perforated Chimney

Stabilizer Rings

Increase or decrease Air Ring blower speed to change venturi air flow and frost line height

Increase or decrease IBC cooling rate (if available) to change melt strength and frost line height

Open / Close holes (if available)

MD Gauge Variation
Helical Instability

Thickness vs. Length
Ultrasonic Sensor Mounting Position

- Uneven pressure distribution in oscillating die air plenums
- Static pressure changes either in cyclic pattern or when rotation changes

Source: D.R. Joseph, Inc.

Evidence of Leaking IBC Air Plenums

± 1.25 cm (½ inch) change in bubble diameter within 12 minute cycle

TD Gauge Variation
Oval Bubble with Thin Bands
TD Gauge Variation
Double Peak Gauge Profile

Common Causes
- uneven melt flow inside die
- die too cold (10 to 20ºC / 20 to 40ºF)
- back pressure too high
- dirty screens
- plugged air ring or IBC stack
- too much drag resistance in collapsing frame

Dirty IBC Stack

TD Gauge Variation
Oval Bubble with Thick Bands
TD Gauge Variation
Double Peak Gauge Profile

- Collapsing Frame
- Linear Plot
- Polar Plot

Common Causes
- Uneven melt flow inside die
- Die too cold (10 to 20ºC / 20 to 40ºF)
- Back pressure too high
- Dirty screens
- Plugged air ring or IBC stack

TD Gauge Variation
Equal Number of Thick and Thin Bands

- Collapsing Frame
- Linear Plot
- Polar Plot

Common Causes
- Uneven melt flow inside die
- Die too hot (10 to 20ºC / 20 to 40ºF)
- Back pressure too low
- Dirty screens
- Melt temperature variation too large (worn screw)
- Too much output
- Plugged air ring or IBC stack
Bottom of Die is Too Cold

Loose Die Heater Bands

Cold Spots in Die

Heater clamps should not be lined up.

No heat supplied in this area.
Dirt Between Die and Air Ring

Common Air Distribution Problems
Uneven air flow from plenums
Uneven air hose length
Kinked, leaking or melted air hoses
Air hoses with sharp 180° bends

Air Hoses Too Close to Hot Spots
Surging
Watch the Chorus Line

- All 3 parameters move up and down together
- Look for speed of cycle compared to screw speed

Solids Bed Ratio
Indicates Melting Capacity of the Screw

\[
\text{Solids Bed Ratio} = \frac{\text{Solids Bed Width}}{\text{Channel Width}}
\]

Solids Bed Wedging
Barrier Screw (unmelted pellets and black specs)

Intense friction plugs Solids Bed Channel and burns resin

Unmelted pellets enter Melt Pool

Melt Film

Solids Bed plugs melt flow

Conventional Screw
(unmelted pellets)
Melting Related Surging
63.5 mm (2-½") 28:1 L/D Barrier Screw, 60 RPM, 110 kg/hr (245 lb/hr), 1 MI LLDPE
Solid Bed Wedging
Caused by melting TOO QUICKLY

1. Lower Feed Zone temperature slightly
2. Raise Zone 2 to soften resin more quickly
3. Reduce output rate (screw RPM)

Solids Bed Break-up

Conventional Screw
(unmelted pellets)

Barrier Screw
(unmelted pellets and black specs)

Unmelted pellets enter Melt Pool
Melt Film
Melt Pool
Solids Bed Channel
Channel and burns resin
Intense friction plugs Solids Bed

Melting Related Surging
63.5 mm (2-½") 28:1 L/D Barrier Screw, 60 RPM, 110 kg/hr (245 lb/hr), 1 MI LLDPE
Unstable Solid Bed Break-up
Caused by melting TOO QUICKLY
Test for Surging

High ridges

Low valleys

Cut 2 sets of 5 layers across roll at peak and valley exactly the same width
Weight is the same = NOT surging
Weight is different = surging

Thank You

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