Enhancing Film Performance via Resin and Structure Selection

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Enhancing Film Performance via Resin and Structure Selection

- Using material selection and film structure design, film manufacturers can optimize film performance and cost.

- In this presentation, four film structures will be introduced:
  - High visual impact collation shrink films
  - Moisture barrier films for dry foods packaging
  - Stretch hooder films for product unitization
  - Typical oxygen barrier structures
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High Visual Impact Collation Shrink Films
Collation Shrink Market

• Low Visual Impact Films
  – Break-bulk product distribution, club store bulk packaging, etc.
  – No significant optical property requirements
  – Usually not printed
  – Mostly monolayer films

• High Visual Impact Films
  – Bottled water/beverages, bundled consumer products, etc.
  – Significant optical property (haze, gloss) requirements
  – Often heavily printed
  – High growth due to increased popularity of bottled water, replacement of other packaging materials, product bundling
  – Monolayer and three-layer films

Source: Internal LBI Market Study
High Visual Impact Collation Shrink Market

• Film Structures
  – Monolayer Structure
    • LDPE rich shrink engine
    • HDPE or LLDPE added for modulus or toughness
  – Three-Layer Structures (10-20% skin layer thickness)
    • Skins: LLDPE / LDPE blend for clarity, gloss and toughness
    • Core: LDPE rich shrink engine with HDPE or LLDPE added for modulus or toughness

• Market Drivers and Needs
  – Downgauging to improve cost and environmental footprint
  – Eliminate trays – again for cost and sustainability
  – Enhanced visual appearance – point of sale
    • Excellent transparency for reverse printing
  – Increased package robustness – tight package

Typical Three-Layer Structure

10-20% Skin
60-80% Shrink Core
10-20% Skin
Monolayer or Three-layer?

- Advantages of monolayer
  - Lower capital cost outlay/depreciation cost
  - Reduced operating complexity

- Advantages of three-layer
  - More flexibility in resin selection
    - single resin or blend does not have to provide all of the film features
    - especially important when balancing optical and physical properties
Formulated Monolayer Shrink Film Study: Optimum Critical Property Retention

1/MD Creep @96 hrs.  Improved >400%

1/Blocking

1/Haze

1/TD Creep @96 hrs.

Contraction Force

MD Modulus

Gloss, 45 deg.

MD Tensile Yield

Dart Drop

Puncture Energy

MDPE/mLLDPE Blend

LDPE Commercial Control
Isothermal Shrink and Contraction Forces

Isothermal Method - LD Control
Machine direction
Peak Contraction Force

Isothermal Method - MDPE/mLLDPE Blend
Machine direction
Peak Contraction Force

Source: Artec Testnology
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Moisture Barrier Films Used in Dry Foods Packaging
MMW HDPE Barrier Market Overview

- HDPE based barrier films are typically used by consumer goods producers for cookie, cracker, cereal and dry powder packaging

- Moisture barrier and sometimes oxygen (aroma and flavor) barrier properties in these applications are critical for food shelf life and maintaining freshness

- Product packaging requirements include moisture and oxygen barrier, low taste and odor, stiffness, tear strength and puncture
Customer Dry Foods Packaging Market

• Film Structures
  – Three-layer blown film structures are most common
  – If oxygen barrier is required, five- and some seven- and nine-layer structures are utilized

• Market Drivers and Needs
  – Downgauging for lower cost and film sustainability
    • Must meet minimum barrier and toughness requirements
  – Foil replacement – again for cost and film sustainability
  – Toughness improvement for existing high-demand applications
    • Such as food products with sharp edges

Typical 3-Layer Structure

- 10-15% Seal
- 50-60% Barrier HDPE
- 25-35% Barrier HDPE
Dry Foods Packaging
Film Structure Examples

**Control Structure**
- 15% Seal
- 50% High Barrier HDPE
- 35% Std. Barrier HDPE

**Improved Barrier Structure**
- 15% Seal
- 50% High Barrier HDPE
- 35% High Barrier HDPE

**Film Gauge Reduction**
- 15% Seal
- 50% High Barrier HDPE
- 35% High Barrier HDPE

**Maximize Toughness**
- 15% Seal
- 50% High Barrier HDPE
- 35% mLLDPE

**Barrier, Toughness & Stiffness**
- 15% Seal
- 50% High Barrier HDPE
- 35% High Toughness HDPE
**Multilayer Structure Optimization**

- Maximize Barrier
- Gauge Reduction

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**Seal Layer**
- (15% of total gauge)

**Core Layer**
- (52% of total gauge)

**Skin Layer**
- (33% of total gauge)

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**WVTR vs. Gauge**

- **Gauge** vs. **WVTR @ 90% RH (g/100 in²/day)**

<table>
<thead>
<tr>
<th>Units</th>
<th>Control Film</th>
<th>High Barrier Film</th>
<th>Gauge Reduction + High Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealt Layer - 15% of gauge</td>
<td>Sealant</td>
<td>Sealant</td>
<td>Sealant</td>
</tr>
<tr>
<td>Core Layer - 52% of gauge</td>
<td>Std. HDPE</td>
<td>High Barrier HDPE</td>
<td>High Barrier HDPE</td>
</tr>
<tr>
<td>Skin Layer - 33% of gauge</td>
<td>Std. HDPE</td>
<td>High Barrier HDPE</td>
<td>High Barrier HDPE</td>
</tr>
<tr>
<td>Film gauge</td>
<td>mils</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>WVTR @ 90% RH</td>
<td>g/100 in²/day</td>
<td>0.101</td>
<td>0.067</td>
</tr>
<tr>
<td>Dart Drop (F50)</td>
<td>grams</td>
<td>61</td>
<td>59</td>
</tr>
<tr>
<td>Tear (MD)</td>
<td>grams</td>
<td>46</td>
<td>45</td>
</tr>
<tr>
<td>1% Secant Modulus (MD)</td>
<td>psi</td>
<td>136,000</td>
<td>128,000</td>
</tr>
<tr>
<td>%Haze</td>
<td>%</td>
<td>39</td>
<td>28</td>
</tr>
</tbody>
</table>

*All films produced on a 6” die with 60 mil die gap at 150 lbs/hr, 2.2:1 BUR and 32” frost line*
Multilayer Structure Optimization

- **Toughness Retention at Reduced Gauge**

![Layer Structure Diagram]

<table>
<thead>
<tr>
<th>Units</th>
<th>Control Film</th>
<th>Reduced Gauge</th>
<th>Optimized @ Reduced Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal Layer - 15% of gauge</td>
<td>Sealant</td>
<td>Sealant</td>
<td>Sealant</td>
</tr>
<tr>
<td>Core Layer - 52% of gauge</td>
<td>Std. HDPE</td>
<td>Std. HDPE</td>
<td>High Barrier HDPE</td>
</tr>
<tr>
<td>Skin Layer - 33% of gauge</td>
<td>Std. HDPE</td>
<td>Std. HDPE</td>
<td>Tough HDPE</td>
</tr>
<tr>
<td>Film gauge (mils)</td>
<td>2.3</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>WVTR @ 90% RH (g/100 in^2/day)</td>
<td>0.101</td>
<td>0.143</td>
<td>0.122</td>
</tr>
<tr>
<td>Dart Drop (F50) grams</td>
<td>61</td>
<td>56</td>
<td>54</td>
</tr>
<tr>
<td>Tear (MD) grams</td>
<td>46</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td>1% Secant Modulus (MD) psi</td>
<td>136,000</td>
<td>133,000</td>
<td>115,000</td>
</tr>
<tr>
<td>%Haze</td>
<td>39</td>
<td>32</td>
<td>23</td>
</tr>
</tbody>
</table>
HDPE Barrier Films Used in Extrusion Lamination Applications

• HDPE-based barrier films can be used as a laminating film for packaging applications
  – Value-added method to meet MVTR requirements

• Value Proposition
  – Reduces cost by replacing foils and metalized films in over-engineered packages
  – Improves package sustainability and reduces environmental footprint
  – Provides flexibility of package design for barrier requirements
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Stretch Hooder Films Used in Product Unitization
Stretch Hood Applications

- **Petrochemical**: Low stretching ratio, but strong holding forces
- **Cement Bags**: Low stretching ratio, dust protection but robust on packaging line
- **Building materials**: Low stretching ratio, but strong puncture & tear performance
- **Beverages**: High stretching ratio + perforated hood = robust stretching + tear performance
- **Appliances**: Fast speed process + robust stretching performance @ low thickness
**Stretch Hooder Market**

- **Film Structures**
  - Market has transitioned to 3-layer coex (typically 20/60/20)
  - Gauge (2 to 6 mil)
  - Core: Stretch engine/puncture
    Skins: Enhanced toughness/optics

- **Market Drivers and Needs**
  - Gauge reduction to improve cost
  - Enhanced stretching capability (packaging line and film) for improved cost and enhanced holding force
  - Films with improved vertical stretching-ability for better load stability
Three-layer TPO-based Structures
Improved Puncture Resistance

* mLLDPE Skin / Core Layer TPO Blend / mLLDPE Skin (Layers thickness 20:60:20)
Three-layer Structures
True Stress vs. Film Composition*

*‘Residual Stress’ divided by ‘Film Thickness on load’ times ‘Initial film thickness’ (80µm)
Core Layer Blend Versatility

LDPE rich core

- MODERATE STRETCHING CAPABILITY
- HIGH-HOLDING FORCES

TPO rich core

- LOW-BUR SENSITIVITY
- HIGH-STRETCHING CAPABILITY (both horizontal + vertical)
- IMPROVED PUNCTURE RESISTANCE
- IMPROVED TEAR PERFORMANCE
- GAUGE REDUCTION CAPABILITY
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Typical Oxygen Barrier Structures
## Typical Five-layer Coextruded Structure

<table>
<thead>
<tr>
<th>Layer</th>
<th>Percentage</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POLYETHYLENE</strong></td>
<td>40-65%</td>
<td></td>
</tr>
<tr>
<td>Tie Layer</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Barrier layer (Polyamide, EVOH)</td>
<td>10%</td>
<td>2-5 mils</td>
</tr>
<tr>
<td>Tie Layer</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td><strong>POLYETHYLENE</strong></td>
<td>15-40%</td>
<td></td>
</tr>
</tbody>
</table>
## Typical Seven-layer Coextruded Structure

<table>
<thead>
<tr>
<th>Layer</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>POLYETHYLENE</td>
<td>35-50%</td>
</tr>
<tr>
<td>Tie Layer</td>
<td>5%</td>
</tr>
<tr>
<td>Polyamide</td>
<td>5%</td>
</tr>
<tr>
<td>EVOH</td>
<td>6%</td>
</tr>
<tr>
<td>Polyamide</td>
<td>5%</td>
</tr>
<tr>
<td>Tie Layer</td>
<td>5%</td>
</tr>
<tr>
<td>POLYETHYLENE</td>
<td>15-35%</td>
</tr>
</tbody>
</table>
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