The Effects of Process and Cooling on Film Properties

A Comparison of Blown, Cast, and Water Quench Extrusion Technology

WPA Conference
Newport Beach, CA June 21-23, 2016

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Agenda

• Introduction to W&H
• Extrusion Technology Basics
  • Cast
  • Blown
  • Water Quench
• Comparison of Film Properties
• In-House Experiment
• Customer Case Study
• Summary
W&H Product Offering Is Unique In Its Scope & Diversity
W&H Extrusion Equipment

Cast Film  Blown Film  Water Quench

FILMEX  VAREX II OPTIMEX  AQUAREX

MDO & Annealing  Winding Technology

FILMATIC series
Co-extrusion Portfolio for Barrier Film

Cast Film

Blown Film

Water Quench

FILMEX

VAREX II

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FILMEX – Cast Film Line for Barrier Film

- Extruder
- Feedblock + Die
- Thickness Gauge
- Chill Roll
- Corona Treater
- Winder

net width: ≤ 160"
layers: ≤ 11 (17*)
output: ≤ 4,400 lbs/h

* nanolayer

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FILMEX – Cast Film for Barrier Film
Development of Layers and Working Width

Number of layers and working width over time from 1995 to 2015.

- Number of layers:
  - Maximum: Increases from 5 to 17 layers.
  - Standard: Remains constant at 5 layers.

- Working width:
  - Maximum: Increases from 80” to 160”.
  - Standard: Increases from 80” to 120”.

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VAREX – Blown Film Line for Barrier Film

- Extruder
- Die head
- Air ring
- Calibration cage
- Layflat unit
- Reversing haul-off
- Winder

Specifications:
- Width: ≤ 142"
- Layers: ≤ 11
- Output: ≤ 2,200 lbs/h
W&H Blown Film Lines
Historical Number of Layers

- 1990: 1 layer
- 2000: 3 layers
- 2010: 5 layers
- 2020: 7 layers
- Forecast: 11 layers

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AQUAREX –
Water Quench Blown Film Line for Barrier Film

- width: ≤ 72"
- layers: ≤ 11
- output: ≤ 1,800 lbs/h

extruder
die head
water calibrator
layflat unit
reversing haul-off
drying
annealing station
winder

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## Strengths of Extrusion Processes for Barrier Films

<table>
<thead>
<tr>
<th></th>
<th>Cast</th>
<th>Blown</th>
<th>Water Quench</th>
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</thead>
<tbody>
<tr>
<td><strong>strengths</strong></td>
<td>• high volume orders</td>
<td>• fast format changes</td>
<td>• zero edge-trim</td>
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<tr>
<td></td>
<td>• optical properties and</td>
<td>• zero edge-trim</td>
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<tr>
<td></td>
<td>thermoformability</td>
<td></td>
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<tr>
<td><strong>typical output</strong></td>
<td>&gt; 1,800 lbs/h</td>
<td>&lt; 1,800 lbs/h</td>
<td>&lt; 1,800 lbs/h</td>
</tr>
<tr>
<td><strong>typical film thickness</strong></td>
<td>&gt; 100 µm</td>
<td>&lt; 140 µm</td>
<td>100 - 200 µm</td>
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</tbody>
</table>
Flexibility in Film Width

Cast  to  Blown  to  Water Quench
Different Processes → Different Film Properties

- Time
- Temperature [°C]
- Melt
- Frost line
- Ambient

**Differential Scanning Calorimeter**

- Cristallinity [%]
- Film thickness [μm]
- 50μm
- 100μm

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**AQUAREX**

- Blown
- Cast
Comparison (W&H In House Experiment) AQUAREX vs. Cast Film vs. Blown Film

Production of identical barrier films on all three extrusion technologies

- 7-layer-film
- Asymmetric structure
- PA6 and CoPA

PA
Tie
PE
Tie
PA
Tie
Seal

100 μm + 230 μm

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Asymmetric Barrier Film for Lid and Tray

100 µm

230 µm

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Various Converting Machines used with Barrier Films

Thermoforming machine

Vertical flat bag machine

Vertical tubular bag machine

Horizontal tubular bag machine

Horizontal flat bag machine

source: Wipak
Why Asymmetric Barrier Films?

- Temperature resistant outer layer (e.g. PA, PET, PP)
  - increased sealing temperature
  - reduced cycle time
  - increased life-time of teflon tapes

- Solutions:
  - lamination with OPA or PET
  - asymmetric co-ex film (e.g. PA/tie/PE)

- Asymmetric film structures can be produced on AQUAREX versus conventional blown with significantly less curling!

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In-House Comparison
AQUAREX vs. Cast Film vs. Blown Film

gloss (ISO 2813) angle 20°, MD

- AQUAREX PA6
- AQUAREX CoPA
- CAST PA6
- BLOWN CoPA

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In-House Comparison
AQUAREX vs. Cast Film vs. Blown Film

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Strength [N/mm²]</th>
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<tbody>
<tr>
<td>AQUAREX PA6</td>
<td>46</td>
</tr>
<tr>
<td>AQUAREX CoPA</td>
<td>45</td>
</tr>
<tr>
<td>CAST PA6</td>
<td>44</td>
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<tr>
<td>BLOWN CoPA</td>
<td>43</td>
</tr>
</tbody>
</table>

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In-House Comparison
AQUAREX vs. Cast Film vs. Blown Film

dyn. impact stress (ISO 7765-1)

Fs [N/mm]

AQUAREX PA6
AQUAREX CoPA
CAST PA6
BLOWN CoPA

230µm
Comparison of Film Properties
tray film, 230 µm

optical properties
- haze
  - blown
  - cast
  - water quenching

mechanical properties
- stiffness
  - blown
  - cast
  - water quenching

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Comparison of Thermoformability
tray film, 230 µm

thermoforming machine

testing of thermoformability

[Multivac]

cast
blown
water quenching

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Product Development for Oil-pouches; A Customer Case Study

- Typical packaging for edible oil in India
- Today’s Status:
  - PE-Film without barrier
    - Leakage
    - Diffusion of oil through the film
    - Limitations during the filling process
    - Adhesion to the sealing bars
    - Reduction of cycle times
    - Machine stop due to maintenance
- Using laminates
  - BOPA back-printed
    - Thermal stability for sealing
  - PE-film for mechanical properties
- Coextrusion of asymmetric film
Formation of Curling during Conventional Blown Film Extrusion of Asymmetric Structures

PE frost line: 245-175 °F
PE solidifies + shrinks
PA solid

PA frost line: 350-285 °F
PA solidifies + shrinks
PE in a molten phase + elastic

at the outlet of the die
>430°F
complete structure in a molten phase
AQUAREX: No Curling due to Cooling Efficiency

at the outlet of the die
>430°F
complete structure in a molten phase

water quenching:
PA + PE solidify + shrink
Product Qualification „Made in India“!

- Recipe development
  - cooperation film producer / oil-producer
- Production of film
- Surface printing
- Filling of the Pouches
  - Increase of cycle time 25 to 40 pouches/min.
  - Prolonging the intervals of maintenance
- Logistic-test
  - Packed in cardboard boxes
  - 2000 km transportation on Indian roads
  - Result: zero-leakage!
Barrier Film Segments

- lid film
- agri film
- lamination film
- water-quenching
- blown
- cast
- pouch / bag film
- thermoforming film
Summary

• All technologies have process related advantages.

• It has to be clarified which technology is best for each application or project.

• Windmöller & Hölscher …
  … has many years of experience in all presented extrusion technologies and can assist with choosing the right technology for the specific application and customer needs.
Thank you for your kind attention!

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