Barrier Solutions in Injection Moulded Containers for Food Packaging

Injection Moulding Forum 13.-14.4.2011
Elina Myhre, Senior Technologist, Norner Innovation AS
Topics of the day

• Norner Innovation – brief company introduction

• Consumer trend supporting barrier development

• Competitive environment in food packaging

• Applicable oxygen barrier technologies for IM containers

• Oxygen barrier calculation model
Norner is…

• Plastics and polymer institute
• International innovation company
• Clients through the plastic value chain

>60 Scientists, polymer technologists, end user specialists, lab and conversion engineers.
International innovation projects

4000m² Scientific Laboratories

• Our vision

Innovation through Insight
Plastics development and support

- International plastics and polymer institute
- Projects for plastics manufacturers, converters and brand owners
- Wide international network in polymer technology and applications

- Innovation projects
- Technical studies
- Consulting
- Troubleshooting

- Partner for development and technical support
Norner key competencies

- Plastics, processing, products and packaging
- Additives, chemicals, REACH and compounding
- Polymers, Catalysts, Gas, Polymerisation and Process
- Advanced Laboratories
Our core competence - The Plastic Market & Value Chain

Upstream Oil & Gas  Plastic Production  Conversion to Products  End Use - You and I
Processing lines

2 Blow Moulders

3 Blown film lines + MDO

5 Injection Moulders

1 Rotomoulder
Examples from our facilities

Polymerisation

Microscopy

Package testing

Food contact
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<table>
<thead>
<tr>
<th>Consumer and market trends</th>
<th>Food packaging requirements</th>
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<tbody>
<tr>
<td>Single household</td>
<td>Ready made meals &amp; convenience food in innovative packaging</td>
</tr>
<tr>
<td>More working women</td>
<td>Portion control, smaller portion packages</td>
</tr>
<tr>
<td>Cash rich (relatively); time poor consumers</td>
<td></td>
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<tr>
<td>Health awareness</td>
<td>Less preservatives, higher barrier requirement for package</td>
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<tr>
<td>Environmental awareness</td>
<td>Weight reduction of packaging material</td>
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<td>Energy efficient transport</td>
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<td></td>
<td>Space and weight savings</td>
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<td>Reduction of food waste by longer shelf life</td>
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<tr>
<td>Differentiation</td>
<td>Shelf appeal, modern expression</td>
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<td></td>
<td>Injection moulding freedom of design</td>
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<tr>
<td>Feature</td>
<td>Glass Jars</td>
</tr>
<tr>
<td>---------------</td>
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</tr>
<tr>
<td>$O_2$ barrier</td>
<td>✓</td>
</tr>
<tr>
<td>$H_2O$ barrier</td>
<td>✓</td>
</tr>
<tr>
<td>Design freedom</td>
<td>✓</td>
</tr>
<tr>
<td>Safety</td>
<td>-</td>
</tr>
<tr>
<td>Weight</td>
<td>-</td>
</tr>
<tr>
<td>Image</td>
<td>✓</td>
</tr>
</tbody>
</table>
Product launches of baby food by packaging material (France, Germany, UK, Spain, Italy)
NaturNes –Baby Food Innovation

Source: www.nestle.com
NaturNes – Baby Food Innovation

“NaturNes is a baby food made from 100% natural ingredients. The recipes have been created to meet the highest nutritional standards and to ensure that the food tastes great. A novel steam cooking technology was developed to preserve these qualities.

The packaging was also redesigned taking into consideration both the consumer and the environment.

Source: www.nestle.com
NaturNes – Baby Food Innovation

Modern, convenient packaging

The pack features light and stackable plastic bowls with re-closable lids for freshness. The design reflects *consumer convenience and safety*. Parents can hold the plastic bowl in their hand when feeding their baby; it has a solid base so it does not tip when children start to feed themselves.

Packaging with reduced environmental impact

Using *Life Cycle Analysis* of environmental impacts across the lifecycle of its products, Nestlé works to improve the environmental performance of its products. For *NaturNes* baby food, *lightweight plastic bowl packaging has been selected over traditional glass jars to help deliver a 25% reduction in CO2 emissions and energy consumption in production and transportation*.

Source: [www.nestle.com](http://www.nestle.com)
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• Applicable barrier technologies for IM containers

• Oxygen barrier calculation model
• 2K injection with EVOH barrier layer
• In mould labelling with barrier label
• Coating
2K Technology: co-injection nozzle and filling

Source: www.kortec.com
Skin: Polypropylene
Core: EVOH
Skin: Polypropylene
Test run 11
A / B / A multilayer structure, 10 % core

Thickness bottom 90 µm, corner 30 µm, sidewall 30 µm, top 65 µm

Test run 12.
A / B / A multilayer structure, 20 % core

Thickness bottom 100 µm, corner 15 µm, sidewall 95 µm, top 140 µm
PP / EVOH / PP container
0,5 liter

Comments:
The barrier layer (EVOH) is continuously in the cup from the cavity 1 and 2.
In some areas, the barrier layer is very thin (<20 μm). (Sampling point 3).
The microscopy investigation reveals that the barrier layer is not continuously in the top edge (image 6b).
There is no significant difference in the layer structure in cups from cavity 1 and 2 or from different sampling points around the cups.
The microscopy investigation shows a delamination between the skin layers (PP) and barrier layer (EVOH) in and nearby the inlet point.
Oxygen Transmission Rate - Theoretical vs measured

• Wall thickness total 0.6mm; EVOH layer 20µm
• Top radius 5.7cm; Bottom radius 4.5cm; Height 6.8cm

• Oxygen Transmission calculation model gives (RT, 50%RH)
  • 0.002 ml/(package·day)

• Measured Oxygen Transmission rate at RT /50% RH for the cups
  • 0.006 ml/(package·day)
  • 0.006 ml/(package·day)
  • 0.007 ml/(package·day)
Status thin wall turnkey systems available from Kortec

- Single face: 8, 16, 24, 32 & 48 cavity systems
- Stack mould: 2x4, 2x8, 2x16, 2x24, 2x32 cavity systems
- Platform: 200 ton - 1000 ton two shot IM machines

- First commercial production machineries installed and under commissioning (1000 ton, 32 cavity)
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Key requirements for IML film

- Right mechanical and surface properties for a smooth and high quality printing process
- Anti-static properties
- Excellent lay-flat properties

Standard decoration IML films and technology well established

**Challenges in barrier IML:**

- Introducing barrier layer to IML film without loss in other key properties
- Wrap around & bottom label with overlap of all label seams (100% coverage), extreme accuracy required.
PP

Adhesive layer

EVOH barrier layer

Adhesive layer

PP
Barrier IML containers launched

“A plastic container with excellent barrier protection for long shelf life. A see through area and a great design without the risk of breakage. This was what French Lesieur was looking for - and found in SuperLock.”

www.Superfos.com
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Plasmax coating technology by KHS

• Plasma impulse chemical vapour deposition (PICVD) process
  • A vacuum chamber is loaded with bottles
  • A vacuum is then applied and a reaction-gas mixture is introduced that transforms the gas into an energy-rich plasma state

• Coat the interior bottle surface with an extremely thin 10 - 100 nanometer silicone oxide (SiOx) transparent, impermeable layer

• Silicon oxide (SiOx) layer provides the PET bottle almost the good barrier characteristics of a glass bottle.

www.khs.com
New barrier coatings for containers

(Plastics Technology, issue April 2011)

• Cavonic 3D Coating Technologies brings a new barrier coating technology to processors of rigid containers

• Cavonic eco-shield uses plasma-enhanced chemical vapor deposition and physical vapor deposition technologies to add an impermeable barrier coating to molded or thermoformed containers.

• Customized coatings reportedly can be applied to virtually any type of substrate, including PE, PP, PET, PS, and PLA and are also compatible with a wide range of container shapes.

• Cavonic based in Germany offers a complete system including automation, vacuum chambers, and coating chamber integrated in-line with the processing operation.
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• Oxygen barrier calculation model
Oxygen Transmission Rate Calculator

Nomer is an international, industrial and technology partner for Plastic and Material Industries.

**OTR Calculator**

This simulation model estimates the oxygen transmission rate of plastic-packaging material like PP, PET and EVOH. Barrier properties of co-injection multilayer and in-mould-label solutions can be studied and evaluated.

The combination of geometrical options, permeability properties and environmental conditions provides an useful tool when working with the design, development and application of plastic packaging.

**Simulation tool**

<table>
<thead>
<tr>
<th>Film</th>
<th>Cup (Frustrum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuboid</td>
<td>Bottle</td>
</tr>
</tbody>
</table>

**Calculation steps**

1. Define geometry parameters (e.g., length, radius, height).
2. Choose materials (define layer material and thickness).
3. Define environmental conditions (temperature, humidity).
4. Push calculate.
5. View and evaluate calculation results.

**We can offer**

- This model focuses on OTR simulation of multilayer barrier film, multilayer containers and barrier in-mould label containers.
- Nomer AS is involved in several development projects involving other barrier
1. Input: geometry and dimensions

2. Input: Material and wall thickness

3. Input: IML materials, layer thickness and label coverage

4. Input: Conditions

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**Cup (Frustum)**

**Geometry**

<table>
<thead>
<tr>
<th>Radius 1</th>
<th>Radius 2</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 cm</td>
<td>6 cm</td>
<td>11 cm</td>
</tr>
</tbody>
</table>

**Layers**

<table>
<thead>
<tr>
<th>Material</th>
<th>Permeability [(mL-mm)/(m²-atm-day)]</th>
<th>Thickness [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 PP</td>
<td></td>
<td>1200</td>
</tr>
<tr>
<td>2 EVOH 32%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 PP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IML layers**

<table>
<thead>
<tr>
<th>Material</th>
<th>Permeability [(mL-mm)/(m²-atm-day)]</th>
<th>Thickness [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 PP</td>
<td></td>
<td>35</td>
</tr>
<tr>
<td>2 EVOH 32%</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>3 PP</td>
<td></td>
<td>35</td>
</tr>
</tbody>
</table>

**Label coverage (of area without top)**: 100%

**Test conditions**

- **Time**: 1 days
- **Temperature**: 20 °C
### Layers

<table>
<thead>
<tr>
<th>Material</th>
<th>Permeability ([ml.mm]/(m².atm-day))</th>
<th>Thickness [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PP</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>EVOH 32%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>PP</td>
<td></td>
</tr>
</tbody>
</table>

- **Add layer**

### IML layers

<table>
<thead>
<tr>
<th>Material</th>
<th>Permeability ([ml.mm]/(m².atm-day))</th>
<th>Thickness [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PP</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>EVOH 32%</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>PP</td>
<td>35</td>
</tr>
</tbody>
</table>

- **Add layer**

**Label coverage (of area without top)**: 100%

### Test conditions

- **Time**: 1 days
- **Temperature**: 20 °C
- **Rel. humidity**: 50%
- **Oxygen level**: 20.9%

- **Calculate**

### Results

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total thickness</td>
<td>$L = 1.275$ mm</td>
</tr>
<tr>
<td>Permeability, overall</td>
<td>$P = 1.747$ (ml mm)/(m² atm day)</td>
</tr>
<tr>
<td>Area (excluded top)</td>
<td>$A = 0.046$ m²</td>
</tr>
<tr>
<td>Volume, container</td>
<td>$V = 1.048$ l</td>
</tr>
<tr>
<td>Volume, oxygen</td>
<td>$q = 0.013$ ml</td>
</tr>
<tr>
<td>Oxygen transmission rate</td>
<td>$OTR = 0.013$ ml/(package day)</td>
</tr>
<tr>
<td>Oxygen transmission rate</td>
<td>$OTR = 0.286$ ml/(m²-day)</td>
</tr>
</tbody>
</table>
Conclusion

• Consumer trends represent a strong need for an efficient barrier solution in thin wall injection moulding

• Technology development by machine suppliers can be met by material development and give a strong solution.

• Specific 2K multilayer IM technology, barrier IML and coating solutions can be expected to drive strong progress in further substituting glass and metal as well as thermoformed plastics containers.