Foam Injection Molding:
Unique Process Solutions for Light Weighting Automotive Plastic Parts

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AGENDA

• Technology Overview
  > Chemical Foaming
  > Physical Foaming
• Foamed LGFPP Light Weighting
• Injection - Expansion Light Weighting
• Application Examples
FOAM INJECTION MOLDING

**BENEFITS**

- Lighter Weight
- Lower Cost (less material, faster cycle, lower injection pressure, higher yields)
- Increased Design Freedom
- Improved Sound, Vibration Absorbency
- Improved Heat Insulation
- Faster to Market (fewer tooling reiterations)
HISTORY OF FOAMED POLYMERS

- **1900**: First Foamed Natural Rubber
- **‘10**: Introduction of Thermoplastics
- **‘20**: Chemical Foaming Agents
- **‘30**: Physical Foaming Agents
- **‘40**: Microcellular Extrusion
- **‘50**: Microcellular Injection Molding
- **‘60**: Structural Foam Molding
- **‘70**: Focused Research Microcellular Foaming
- **‘80**:
- **‘90**:
- **2000**:
- **‘10**:
FOAMING PROCESS THEORY

• Single Phase, Polymer – Supercritical Fluid (SCF) Solution.

• Nucleation

• Cell Growth

• Stabilization
CHEMICAL FOAMING

• Chemical Foaming Agent (CFA) added to resin as masterbatch or compounded.
• At decomposition temperature in the barrel, decomposed additives produce an atmospheric gas. (N\textsubscript{2} or CO\textsubscript{2})
• Mostly heterogeneous nucleation with pressure drop during injection.
• Cell growth and stabilization in the mold cavities.
CHEMICAL FOAMING

*Process Advantages:*
- Ideal for larger wall thickness. (> 6mm, 1/4”)
- No upfront capital investment, economical foaming solution for low volume production.

*Process Disadvantages:*
- Narrower molding process window.
- Larger cell size, less cell density, less predictable, heterogeneous material structure.
- About 50% of CFA decomposes into gas, remaining additives stay in polymer.
CHEMICAL FOAMING

3 Parts on the left, MuCell® with different gas levels, part on the right CFA
Physical / MuCell® FOAMING

**Basic Steps**
- Melt plastic prior to SCF injection
- Inject SCF during screw rotation
- Dissolve SCF into the polymer melt (single phase solution)

Diffusion Complete

[Diagram showing the process of physical/MuCell® foaming with steps indicated by arrows and icons showing SCF and polymer phases.]
Supercritical Fluid (SCF)

- SCF: Low compressibility, high diffusivity
- CO$_2$: $P_c$ 1050 psi/71 bar, $T_c$ 88°F/31°C
- N$_2$: $P_c$ 500 psi/34 bar, $T_c$ -233°F/-147°C
PHYSICAL FOAMING

Complete Cross-Section

Skin
Foam core
Skin
PHYSICAL FOAMING

Process Advantages:
- Ideal for smaller wall thickness (< 6mm, 1/4”)
- Homogeneous, microcellular material structure with skin formation.
- Reliable, repeatable closed loop process.
- No chemical alteration of polymer, no residue.

Process Disadvantage:
- Upfront capital investment in SCF delivery & dosing hardware, special plasticizing unit.
DESIGNING FOR MuCell®

⇒ Filling from “thin to thick“

Recommended injection with Microcellular Foam

⇒ Wall to rib ratio 1:1 possible

Conventional design

Microcellular design

Injection in solid (with MuCell® still possible)
FOAMED LGFPP LIGHT WEIGHTING

Long Glass Fiber PP Advantages:

• Substitution for metal modules and carriers
  ➢ Provides sufficient rigidity and impact strength compared to standard glass fiber
  ➢ Part must avoid shattering upon impact
• Lighter weight than metals with acceptable properties
• Lower cost than metals / solid plastic parts
FOAMED LGFPP LIGHT WEIGHTING

Excellent Property Retention for LGFPP:

Long Glass Fiber MuCell ISO Data
FOAMED LGFPP LIGHT WEIGHTING

Feed Screw Technology Breakthrough:

• Traditional Screw Design resulted in excessive breakage of glass fibers

• New MuCell Screw Design provides excellent retention of fiber lengths

Traditional Screw Design
(Note short fuzzy fibers)

New Trexel Screw Design
(Note long fibers retained)
First to Market MuCell® LGFPP Instrument Panel

Application Information

2012 MY Ford Escape/Kuga Instrument Panel
First to Market MuCell® LGFPP Instrument Panel

~ $3 Cost Saving per Vehicle

Technology Advantages

> 1.0 pound in weight savings
> 15% cycle time reduction
> 45% clamp tonnage reduction

Consumer Benefits

I/P system weight reduction contributes to improved vehicle fuel economy

Green – reduced carbon footprint by using less material and energy to produce parts
INJECTION EXPANSION LIGHTWEIGHTING

⇒ Combining physical foaming process with a secondary expansion process

⇒ Fill mold cavity close to solid weight with SCF laden polymer
⇒ Increase mold cavity volume to allow for uniform expansion

6 mm
INJECTION EXPANSION LIGHTWEIGHTING

Foaming Weight Savings Potential of 30 – 50%!

![Graph showing relationship between wall thickness, relative density, and relative stiffness.](image-url)
LIGHTWEIGHTING APPLICATION
Interior Trim Volkswagen Touran

Design Drivers:
⇒ Energy absorption on impact
⇒ No visible sink marks through PVC layer
⇒ Deletion of “plug-in-module“

<table>
<thead>
<tr>
<th>Conventional Design:</th>
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<tbody>
<tr>
<td>⇒ Base thickness: 4.4 mm</td>
</tr>
<tr>
<td>⇒ Plug in module: 65 g</td>
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<table>
<thead>
<tr>
<th>MuCell-Design:</th>
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<tbody>
<tr>
<td>⇒ Base thickness: 2.2 mm</td>
</tr>
<tr>
<td>⇒ Rib thickness: 2.2 mm</td>
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</tbody>
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Comparison of MuCell Design vs. Conventional Design
⇒ Equivalent or better energy absorption
⇒ Approx. 40 % reduction in part weight
  ❚ 20 % through wall thickness reduction
  ❚ 14 % through deletion of “plug-in-module“
  ❚ 6 % through density reduction
LIGHTWEIGHTING APPLICATION

Fan Shroud BMW

Conventional Design:
- Base thickness: 2.0 mm

MuCell-Design:
- Hub & stators: 2.0 mm
- Air deflection: 1.0 mm

Design Drivers:
- Mechanical strength for hubs and stators
- Minimal wall thickness for air deflection
- Hub and stators 2 mm
- Reduced wall to 1 mm

WEIGHT SAVINGS PER SHROUD: 410 GR / 0.9 LBS.
Thinner general wall (1.8 mm to 2.0 mm)
1:1 wall to rib ratio
> 50 % cycle time reduction (MuCell + Tandem-Mold)
High dimensional stability

Mercedes – Benz Door Carrier
THANK YOU!

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