MuCell® - the foaming process for thin walled products

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ENGEL UK

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MuCell®

Micro-cellular foam

MUCELL® Polyolefin

Conventional Structural Foam (CBA) with Polyolefin

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MuCell®

• Invented in the M.I.T. Polymer Processing Lab
• Commercial development completed by Trexel under worldwide exclusive license from M.I.T.
• MuCell is a proprietary technology available only from Trexel and its OEM partners under MIT and Trexel patents issued and pending.
• Extrusion, Blow Moulding and Injection Moulding
• ENGEL is one of a number of OEM Licensees

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Other IMM OEM licensees for MuCell
MuCell® Presentation Summary

• **MuCell® Technology**

• MuCell process

• MuCell product examples

• Summary
MuCell® Technology

Cost Reduction achieved by:

• **Reduced material cost.**
  - Weight reduction - lower density

• **Reduced cycle time.**
  - Holding pressure and cooling times reduced

• **Reduced capital cost.**
  - Lower clamp force, smaller injection unit

• **Improved quality.**
  - Better dimensional stability.
  - Low moulded-in stress
  - No sink marks
MuCell® Technology

- Equipment technology, not a material additive.
- Small uniform cell structure (10-50 microns)
- Solid skins and micro cellular foam cores
- Good mechanical properties
- Uniform shrinkage

Minlon PA 6.6 MuCell weight reduced 15%
MuCell® Process
SCF - SUPER CRITICAL FLUID
Possesses both gas-like and fluid-like properties
- Low compressibility
- Low viscosity
- Good diffusion/solubility
Achieved at high pressure and temperature

Super critical points
N₂: \( p_c = 33.9 \text{ bar} \)
\( T_c = -147^\circ C \)
CO₂: \( p_c = 73.84 \text{ bar} \)
\( T_c = 31^\circ C \)
MuCell® Technology

- MuCell® Technology
- MuCell process
- MuCell product examples
- Costs
MuCell Process

EQUIPMENT
Special screw (28:1 LD), nozzle and barrel.
Gas generation and delivery system (SCF unit)
Gas injection and control system (MIK unit)
Modified IMM hydraulic system and software
MuCell® Process

Equipment can run both solid and MuCell modes of operation

- N₂ source into barrel
- Shut-off nozzle
- Minor software and hydraulic changes

SCF system supplied by Trexel

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1. Special barrel.
2. Gas feed pipe
3. Gas injectors
4. MIK unit
5. Cooling fans
Main Process Steps

Processing direction

- Metering
- SCF injection
- Dissolution
- Nucleation and growth
MuCell Process
MuCell Process
MuCell®
Benefits

Reduced Cycle Time

Solid

Injection  Hold  Cooling

MuCell

Hold  Cooling

Hold & Pack are almost eliminated  25% less cooling time

20% - 50% Overall Cycle Reduction

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Typical Viscosity Reductions

• 10% to 15% for a 30% glass fiber reinforced semi-crystalline engineering resin
• 20% to 30% for an amorphous resin

This can be observed in:

• Reduced injection pressures
• Reduced melt temperatures
Viscosity reduction

Injection Pressure

Solid 1440 psi

MuCell 950 psi

34% reduction in peak hydraulic pressure at equal fill speeds due to viscosity reduction.
**MuCell™ Benefits**

**Reduced Viscosity**

**Solid**
- Set process conditions
- Part weight 12.72g

**MuCell**
- Add N₂ SCF
- Part weight 12.79g
- No other process changes
- Completely filled the part

In solid, this area could not be filled.

Data Com Connector

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MuCell™ Benefits

Cavity Pressure

- Cavity pressure reduced 57% from 1045 bar to 448 bar
- 4 - 10 % weight reduction

Data Com Connector
30% Glass filled PBT

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**MuCell™ Benefits**

**Uniform Shrinkage**

- **Dimensions are stable over weight reductions of 4% -17%**

<table>
<thead>
<tr>
<th></th>
<th>Dim 4</th>
<th>Dim 6</th>
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</thead>
<tbody>
<tr>
<td>Print</td>
<td>7.31 mm</td>
<td>7.31 mm</td>
</tr>
<tr>
<td>Solid</td>
<td>7.28</td>
<td>7.17</td>
</tr>
<tr>
<td>MuCell</td>
<td>7.29</td>
<td>7.27</td>
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All Thermoplastic materials can be processed using MuCell Technology
No limitation by processing parameters

Commodity materials, PP, HDPE, PS

Engineering plastics, PC, PA, PC/ABS

High Temperature plastics, Polysulfone, Polyetherimide, LCP

Thermoplastic Elastomers, TPE
MuCell® part appearance

• Light swirl surface
• Skin - foam core - skin construction
• Uniform and homogenous cell structure
• Internal core cell sizes less than 100 microns
• Opaque part without colorants
MuCell® Moulding Technology

• MuCell® Technology

• MuCell process

• MuCell product examples

• Costs
MuCell® Moulding Technology

Automotive Bracket - Nylon 6.6 25% mineral and 15% glass filled

- Dimensional improvement with MuCell
- Weight reductions up to 28%
- Cycle time reductions of 50%
  - Solid at 50 seconds
  - MuCell at 24 seconds
### Cost Savings

**MuCell® Automotive Junction Box**

<table>
<thead>
<tr>
<th></th>
<th>Solid</th>
<th>MuCell</th>
<th>Difference (%)</th>
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</thead>
<tbody>
<tr>
<td>Cycle Time</td>
<td>53 sec.</td>
<td>39 sec.</td>
<td>(29%)</td>
</tr>
<tr>
<td>Weight (10%)</td>
<td>.34 lb</td>
<td>.30 lb</td>
<td>(10%)</td>
</tr>
<tr>
<td>Machine Size</td>
<td>300-tons</td>
<td>200-tons</td>
<td>(33%)</td>
</tr>
<tr>
<td>Part Cost</td>
<td>$1.22</td>
<td>$0.97</td>
<td>(20%)</td>
</tr>
</tbody>
</table>

**Annual Cost Savings:** $121K  
**Machine Time Savings:** 1740 hours  
**Smaller Machine – only one instead of two**
MuCell® Moulding Technology

Printer Chassis
PPO 20 % GF
Weight reduction 4.5 %
Warpage minimised (50% improvement)
Cycle time reduced by 13.3%
Clamp force reduced from 420 t to 220 t
MuCell® Moulding Technology

Electrical Connector

Key Benefit

Eliminated sink
Improved sealing surface

Plus

Cycle time reduction 28%
Weight reduction 12%

Business Case

Annual savings - $107,133
Net part savings - 12.75%

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MuCell® Moulding Technology

Air Distribution Housing
PP 20% talc filled
Weight reduction 10%
Warpage minimised
MuCell Automotive Radiator End Tanks

Material: PA 30% Glass Filled

Quality
• Met all requirements for end tank testing

Plus:
• Weight reduced 15%
• Cycle time - 25%
MuCell Automotive Door Lock Housings

- **Weight reduced 10%**
- **Cycle time reduced - 20% - 30%**
- **Machine size reduction up to 50%**

Material: POM & PBT
MuCell® Moulding Technology

Manifold Gasket

DuPont PA 6.6 with 33% glass fibre

- Nominal wall thickness 3mm
  - Over-molding channels with thickness down to 0.75mm

- Cycle Time Reduction - 66%
  - Solid CT 18 seconds
  - MuCell CT 6 seconds

- Clamp Force Reduction – 60%
  - Standard Process - 150Tons
  - MuCell process - 40Tons

- Weight Reduction – up to 20%
Automotive

HVAC door

Quality Improvement
• Eliminated warp over hot / cold temperature range
• Excellent dimensional stability

Cost Reduction
• 30% cycle time reduction
• 10% weight reduction
• Clamp tonnage reduction from 200-t to 30-t

Minlon PA 6/6 glass & mineral filled
Cable Ties

- 10% Weight reduction
- 30% Injection pressure reduction
- 30% clamp force reduction
Automotive Light Trim

- Cycle time reduction 15%
- Weight reduction 10%
- Clamp force reduction 20%
- Warpage minimised 2 mm
- No Sinkmarks
Left Support Bracket  HP 1220 C Printer
Moulded by Avaplas Singapore on
ES 1800/300 HL
SOP: 15.08.2001
MuCell Technology Applications

Door Panel
- PUR foil patented by Linpac and Recticel
- First class grain
- Cavity pressure 40 bar
- ENGEL Tecomelt Technology
• MuCell® Technology
• MuCell process
• MuCell product examples
• Summary
MuCell™ Benefits

Lower Cavity Pressure
- Reduced molded-in stress
- Reduced flash
- Less warp and bow
- Lower clamp tonnage

Reduced Melt Viscosity
- Lower injection pressure
- Lower melt temperature
- Lower tool temperature
- Less tool wear

Uniform Shrinkage
- Dimensional stability

Materials
- Wider material selection
- Complete crystallinity at lower tool and melt temperatures

PLUS:
- Controlled weight reductions
- Faster cycle times
MuCell® Moulding Technology

**BENEFITS**

- Weight reduction – up to 30%
- Cycle time saving – up to 60%
- Smaller clamp force – up to 60%
- Improved dimensional stability
- Better mechanical properties (?)
- Thin wall thickness possible
- Large variations in wall thickness
End User License Summary

- Machine-based master license
- Continuing rights to all Trexel Intellectual Property
- Reciprocal Patent Grants: excellent protection
- 7 Year annual license fee based on machine size
- License fully paid and irrevocable after 7 years
- Trexel supplied support & training plan
ENGEL MuCell – Machines

ES 1800/250 HL with ERHLi-Automation

ES5050/1000 DUO with ERC robot

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The largest MuCell machine
ENGEL DUO 16050/1700
1700 Tonne clamp
10960cc Shot volume
150mm dia. screw
YOUR PARTNER FOR THE FUTURE

THANK YOU