MuCell®

Microcellular Foaming Technology for Injection Molding Industry

MuCell Processes

TREXEL INC.

MuCell® Molding Technology

The most significant plastic processing innovation in the last 20 years

The MuCell® microcellular foam injection molding process for thermoplastics materials provides unique design flexibility and cost savings opportunities not found in conventional injection molding. The MuCell® process allows for plastic part design with material wall thickness optimized for functionality and not for the injection molding process. The combination of density reduction and design for functionality often results in material and weight savings of more than 20%.

By replacing the pack & hold phase with cell growth, lower stress parts are produced which have enhanced dimensional stability and substantially reduce warpage. Cell growth also results in the elimination of sink marks.

Unlike chemical foaming agents, the physical MuCell® process has no tempertature limitation and does not leave any chemical residue in the polymer; making consumer products perfectly suitable for recycling within the original polymer classification and allowing re-grind material to reenter the process flow.

The numerous cost and processing advantages have led to rapid global deployment of the MuCell® process primarily in automotive, consumer electronics, medical device, packaging and consumer goods applications.

Reduced Costs

- Reduced resin consumption
- Faster molding cycle time
- Increased yields
- Smaller molding machine
- Use of lower cost filled polyolefin material

Design Freedom

- Thin to thick wall flow
- 1:1 wall thickness rib structure
- Material where needed for function versus flow
- Improved dimensional stability
- Less warpage

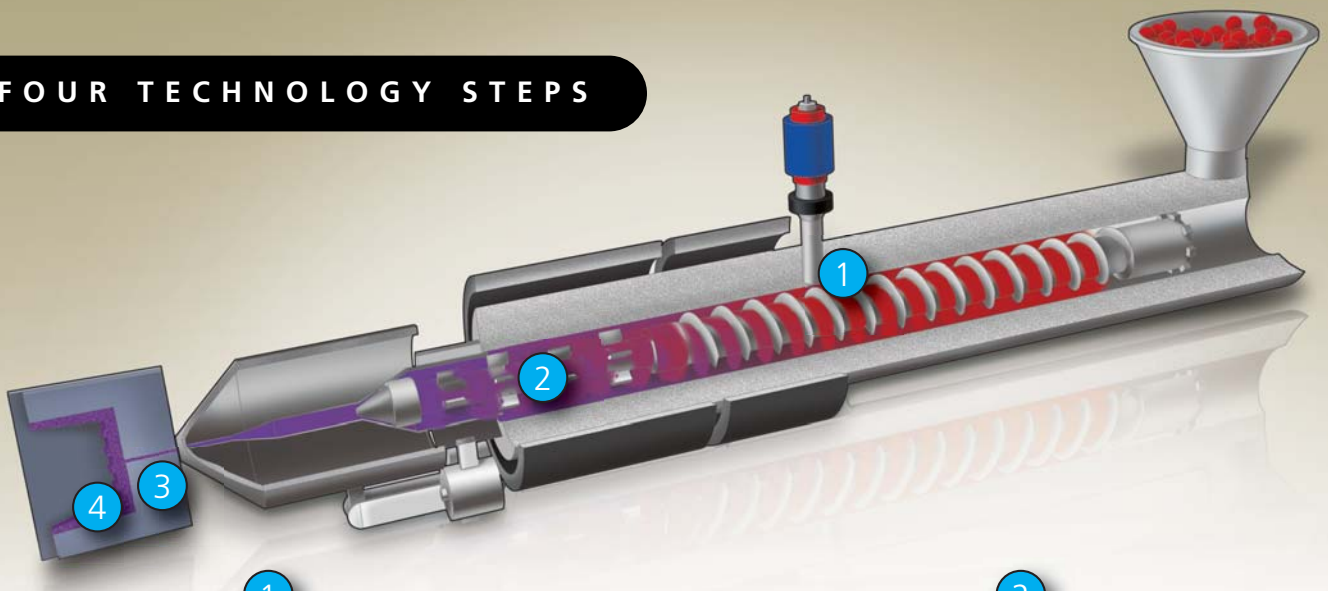
Sustainability

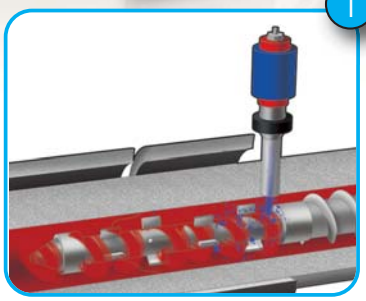
- Reduced petroleum based material consumption
- Reduced molding machine energy consumption
- Ability to re-grind / re-use molded parts
- Reduced carbon footprint versus solid molding

Faster to Market

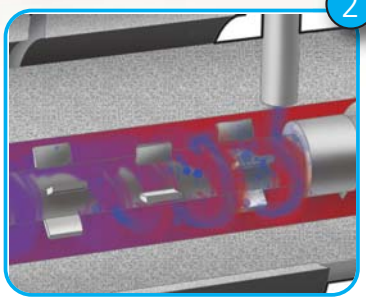
- Fewer tooling iterations
- Predictable molded part geometry
- Ability to mold large parts as single piece

FOUR TECHNOLOGY STEPS

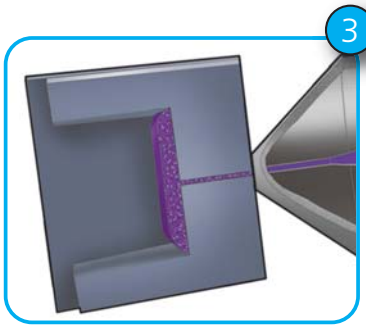




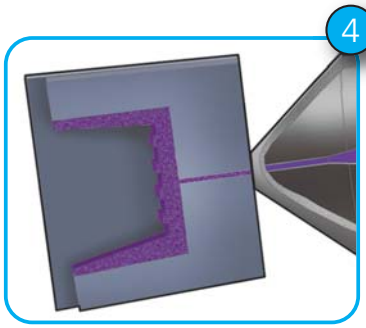
During plasticization, precisely metered amounts of supercritical fluid (SCF), typically Nitrogen or CO_2, are introduced into the polymer through injectors mounted on the plasticizing barrel.



Homogeneous mixing and disbursing of the supercritical fluid into the polymer through the specially designed mixing section of the plasticizing barrel, creates a single phase solution of SCF and molten polymer.



Injection of polymer into mold cavities. Cells start to nucleate once exposed to lower pressure in the mold cavity. Molecular dispersion of SCF provides for a homogeneous closed cell structure with a solid skin layer.



Low pressure filling of mold cavities. Pack & hold phase is replaced by controlled cell growth, which ceases once the mold cavity is filled. Cell growth results in a uniform pack pressure throughout the mold cavity.

MuCell®/ Polymer Value Match

Good Value			Great Value
HDPE	Acrylic	HDPE	Glass
PVC	HIPS	PVC	PP Glass
TPE	HIPS	TPE	PPO Blends
ABS	PA6/6.6 Unfilled	ABS	PSU
TPV	GPPS	TPV	PIE
PP Unfilled	POM	PP Unfilled	PA6/6.6 Glass
TPO		TPO	PBT Glass

Virtually all polymers will develop a cellular structure with the MuCell® process except for LCP. Filled materials tend to offer the greatest value as fillers act synergistically with the supercritical fluid to provide the best combination of weight reduction and cycle time reduction. Unfilled amorphous materials also foam very well and can provide good weight reductions but with less cycle time benefits than filled materials. High temperature materials such as PEEK, PEI and PSU also provide significant cost reduction based on material price.

The MuCell® Application Advantage:

The freedom to design for functionality and not for plastic process limitations

By replacing the tradition pack & hold phase of the solid molding process with cell growth, the MuCell® process allows for uniform and locally applied pack pressure through cell growth. This allows part design to be optimized with material thickness in those areas that require strength and reduced wall thickness in areas that are not structural. Gate locations are then placed in the thin cross sections for optimized filling patterns while allowing the cell growth to provide packing in the thicker cross sections at the end of fill.

Using the same principle, nominal wall thickness can be reduced while using thicker ribs to meet structural requirements. The cell expansion will eliminate sink marks and the cell structure will prevent the formation of vacuum (shrink) voids. Rib to wall thickness ratios of 1:1 can be used with the MuCell® process.

Differences in Wall Thicknesses

Filling from "thin to thick"

Recommended injection with MuCell®

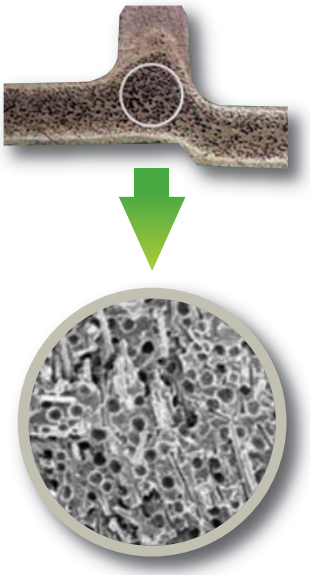
Injection in solid (with MuCell® still possible)

Wall to rib ratio 1:1 possible

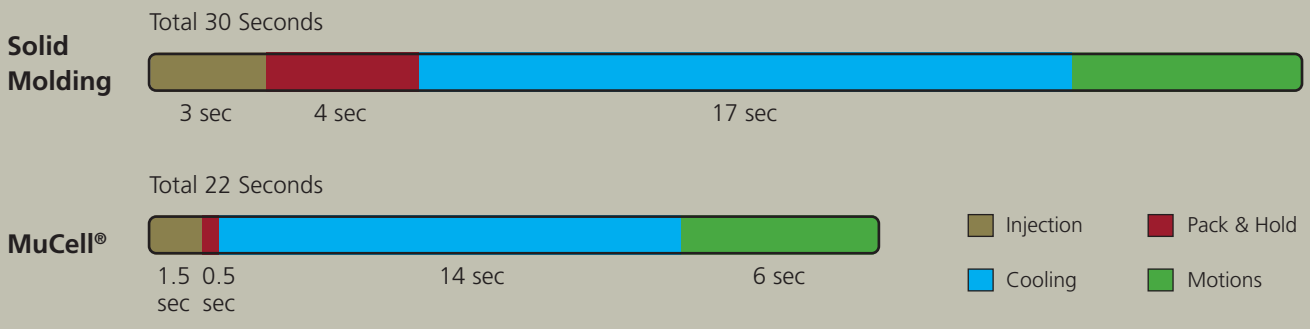
Conventional Design

MuCell® Design

"A part molded with the MuCell® process has a solid skin layer and microcellular foamed core which is a closed cell structure. The cell growth is more effective at packing the part than the solid pack phase which allows for increased rib to nominal wall thickness without sink marks. In most cases, it is possible to produce a sink free part with a rib thickness equal to the nominal wall thickness".



TYPICAL CYCLE TIME REDUCTION WITH MUCELL®



MuCell® Molding Technology

The complete process solution providing for lighter and more accurate plastic parts at lower production costs

Automotive

Climate Control Bezel | *Material:* **Glass filled ABS**

- Elimination of sink marks
- 1:1 ribs to nominal wall
- Machine clamping force reduced from 250 tons to 75 tons
- 23% cycle time reduction
- 10% weight reduction

Packaging

Thin Wall Margarine Container | *Material:* **70 MFR PP**

- 6% weight / material reduction
- 15% reduced injection pressure, reducing washout and allowing for thinner in mold label
- Enhanced freedom of design, thicker sealing lip at the end of fill
- Machine clamping force reduced by 50%

White Goods

Cover Plate | *Material:* **Filled ASA**

- Premium quality surface features
- No sink marks / weld lines
- 30% reduction of material / weight
- 18% reduction of cycle time

Consumer Electronics

Printer Bonnet | *Material:* **20% GF PPO/PS**

- Uniform shrinkage and reduced stress result in improved dimensional stability
- Dimensional compliance achieved with fewer mold iterations

	Key Dimensions	Std Dev Solid	Std Dev MuCell®
Height	(32.43)	0.0100	0.0045
Width	(87.33)	0.0145	0.0025
Length	(32.43)	0.0155	0.0035

APPLICATIONS FOR ALL INDUSTRIES

Automotive Electronics

EMC Connector | *Material:* **Glass Fiber Reinforced PBT**

- 11% weight / material reduction
- 18% cycle time reduction
- Improved pin retention force
- Smaller standard deviation, consistent pin hole size

Consumer

Power Tool Base | *Material:* **PA 6, PA 66**

- 70% warpage improvement
- 8% weight / material reduction
- 18% cycle time reduction

Industrial

Pallet | *Material:* **PP/HDPE**

- 10% reduced weight / material
- Warp reduction for fit / operation of lid
- Machine clamping force reduced by 50 – 70%

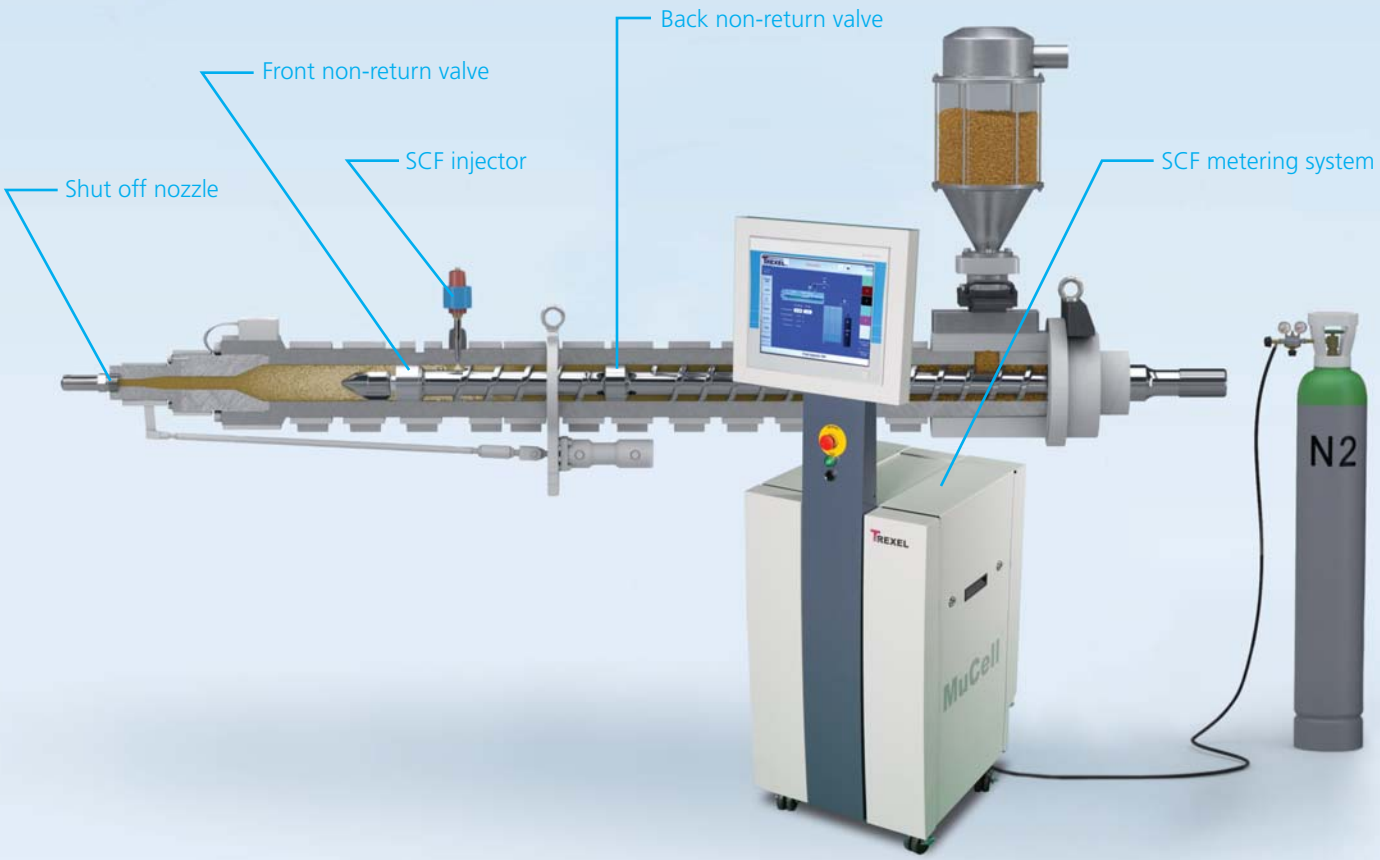
Consumer

Footwear | *Material:* **TPU**

- Light weight sole components, below 0.3 g/cm^3 density
- 40% improved rebound (ASTM D2632)
- Use of high performance resin with lower weight

IMPLEMENTING THE MUCELL® PROCESS

The MuCell® capable injection molding machine consists of Nitrogen or CO_2 supply, a SCF metering and control system, and a specialized plasticizing unit including positive screw control and a shut off nozzle.



The technology can be easily integrated into new (OEM Model) or existing (MMU Model) molding machines:

MODULAR MUCELL® UPGRADE (MMU)

Field retrofit of existing injection molding machines by qualified Trexel technicians. The upgrade consists of a new, MuCell® capable plasticizing unit, positive screw position control, installation and training.

OEM SYSTEM

For new injection molding machine applications, the following licensed Trexel OEM partners can provide a turnkey MuCell® injection molding system.

MILACRON

ENGEL

KraussMaffei

ARBURG

JSW
THE JAPAN STEEL WORKS, LTD.

HAITIAN
PLASTICS MACHINERY

About Trexel

The exclusive provider of the MuCell® Microcellular Foam Injection Molding Technology

The MuCell® Microcellular foaming technology was originally conceptualized and invented at the Massachusetts Institute of Technology (MIT) and in 1995 Trexel was granted an exclusive worldwide license for the further development and commercialization of the technology. Today, Trexel is the exclusive provider of the MuCell® microcellular foam technology for injection molding and maintains an extensive global patent portfolio. Trexel provides world-class engineering support, training and other design and processing services, as well as the equipment and components integral to the MuCell® process.

From the global headquarters in Boston, Massachusetts, Trexel operates a state of the art plastics processing development laboratory, supporting plastics processors with the definition and implementation of leading and differentiating plastic molding technologies.

In support of a global client base, Trexel operates subsidiaries in Europe, Japan and Southeast Asia with competent plastics processing engineering capabilities. Trexel's worldwide subsidiaries are augmented by a network of competent independent representatives and distributors.

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