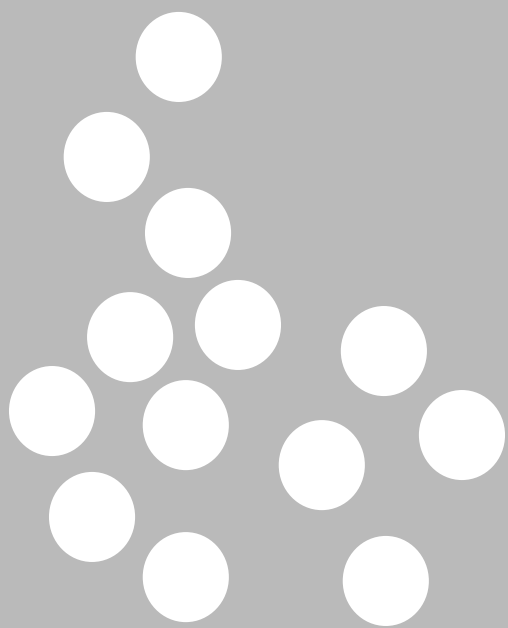
MuCell™ Microcellular Injection Molding Processing Technology



MuCell Processes

TREXEL INC.

MuCell™ Molding Technology

CYCLE TIME REDUCTION◆ WEIGHT REDUCTION◆ CLAMP TONNAGE REDUCTION

New opportunities for injection molders originate from a breakthrough molding technology, offering tremendous capabilities never before seen with other molding processes. MuCell™ opens new markets for innovative product design, optimized processing and reduced part costs. Products manufactured using MuCell technology are being developed and marketed in a variety of industries worldwide, including automotive, medical devices, consumer goods, electronics, food services and industrial and consumer structural parts.

Molders can gain a competitive advantage with the MuCell process by utilizing its processing benefits, e.g. endothermic reaction, lower viscosity and lower melt and mold temperature. These benefits typically result in significant reductions in cycle time, material consumption, injection pressure and clamp tonnage. This microcellular foam process is unique because it can be applied to thin-wall parts and to materials that cannot be foamed successfully with any other foaming technologies. In summary, competitive advantages can be achieved not only in existing markets, but also in new markets.

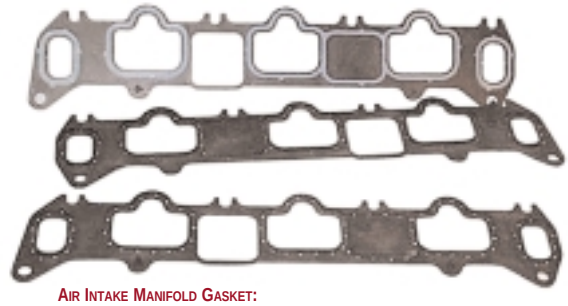
Injection molding applications of the MuCell molding technology have produced the following results:

- Up to 60% reduction in material viscosity due to the introduction of the supercritical fluid
- Significant reductions in processing temperatures (as much as 78°C, 140°F), resulting from lower viscosity
- 30-50% reduction in hydraulic injection pressure
- Reductions in cycle time due to the elimination of hold pressure and time
- Controlled weight savings
- 30-80% reduction in clamp tonnage
- Elimination of sink marks

Polyolefin tubs:
- Thin-wall application of 40 MFI polyolefin material
- Wall thickness - 0.5 mm (0.020")
- Elimination of hold and cooling time
- Flow Ratio = 280:1
- 10% material reduction

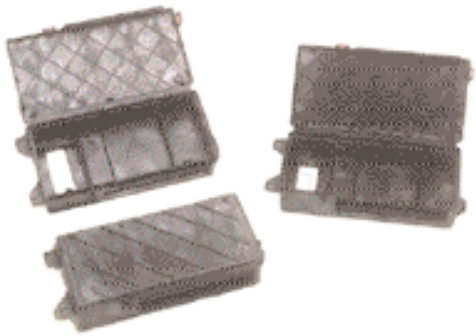
The innovative MuCell microcellular foam process, which was developed at the Massachusetts Institute of Technology (MIT) and Trexel, is covered by patents and patents pending in Asia, Europe and North America. The MuCell molding technology is available as an option on selected new injection molding and structural foam molding machines. All MuCell-capable injection molding machines and structural foam machines are also capable of conventional, non-foaming operation.

Medical Handles:
- PC and Polysulfone
- Up to 30% weight reduction
- 50% cycle time reduction
- Clamp tonnage reduction from 120-tons to 15-tons
- Ability to mold difficult to flow materials



Air Intake Manifold Gasket:
- PA 6/6 - 33% glass-filled
- 66% cooling reduction
- Controlled weight reductions of 5, 10, 15, 20%
- Clamp tonnage reduction from 150-tons to 40-tons

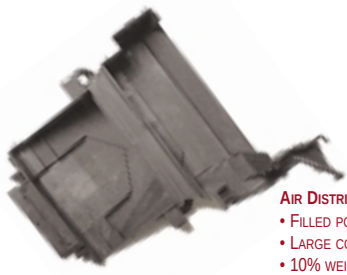
MuCell™ Technology Applications



Fuse Box:
- 22% mica-filled polypropylene copolymer
- 17-20% weight reduction in three dimensional products with varied wall thickness down to 0.5mm (0.0020")
- Living hinge
- Elimination of sink marks

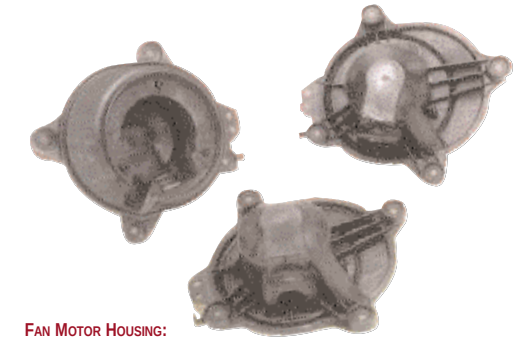
The MuCell™ process technology is being applied to a broad range of injection molded thermoplastic materials and applications. Molders are currently taking advantage of the unique process benefits that MuCell provides. The applications that have been selected take advantage of the controlled weight savings and significant reductions in cycle time. Many products have been converted from larger machines to smaller MuCell equipped machines utilizing the drastic reductions in clamp tonnage. Most notably, the process is being applied in applications never before thought possible with other conventional technologies.

Filled and unfilled materials such as nylon (PA), polycarbonate (PC), polypropylene (PP), polycarbonate/acrylonitrile butadiene styrene (PC/ABS), polystyrene (PS), acetal (POM), polyethylene (PE), high-temperature sulfones, and TPE's, (e.g. Santoprene and Kraton) have been molded.

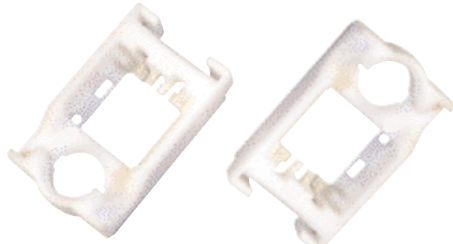


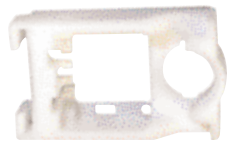
Air Distribution Housing:
- Filled polypropylene
- Large complex mold
- 10% weight reduction
- 20% cycle time reduction

HVAC Door:
- PA 6/6 - 40% glass-filled
- 30% cycle time reduction
- Excellent dimensional stability
- Clamp tonnage reduction from 200-tons to 30-tons



Fan Motor Housing:
- 25% talc-filled polypropylene copolymer
- 15% weight reduction in thin complex shapes
- Elimination of sink marks
- Elimination of hold pressure and time





Acetal High Wear Components:
- Weight reductions up to 40%
- 20% cycle time reduction
- Clamp tonnage reduction from 150-tons to 40-tons
- Ability to mold difficult to flow materials

Automotive Trim:
- PP or PC/ABS
- In-mold decoration
- 28% injection pressure reduction
- Melt process temperature reduction
- Improved fabric/lamination quality
- Elimination of sink marks

MuCell™ Microcellular Process

Four Technology Steps:

1. Gas Dissolution

A supercritical fluid (SCF) of an atmospheric gas (CO_2 and N_2) is injected into the polymer through injectors installed in the barrel to form a single-phase solution. The SCF delivery system, screw and injectors are specifically designed to facilitate the rapid dissolution of the SCF in the polymer.

2. Nucleation

A large number of nucleation sites (orders of magnitude more than with conventional foaming processes) are formed throughout the polymer during the molding process. A substantial and rapid pressure drop is necessary to create the large number of uniform sites.

3. Cell growth

Cell growth is controlled by processing conditions. Precise control of pressure and temperature is achieved through specifically-designed machine controlled hardware and software.

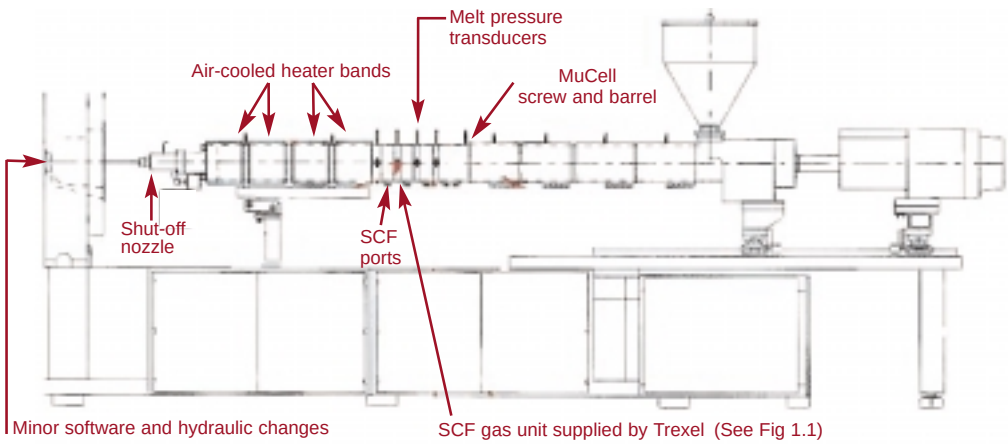
4. Shaping

After injection into the mold, part shape is controlled by the mold design. Although mold modifications are not required, in some cases modifications will optimize the benefits of MuCell™.

Adapting the MuCell process injection molding requires the following changes or additions:

- A SCF metering system with sufficient capacity to deliver the SCF blowing agent to the screw at the rate and pressure required for the MuCell process. (Trexel's Equipment Division supplies properly-configured pump systems for SCF delivery and other proprietary components to licensees)
- A Trexel-designed screw for creating a single-phase solution of the SCF blowing agent. (The screw design allows for both solid and MuCell materials to be processed)
- Minor modifications to software, system hardware and hydraulics to create and maintain the uniformity of the single-phase solution throughout the injection molding cycle

MuCell Machine Requirements



Equipment Modifications

- MuCell Screw and Barrel
- Barrel modifications
- MuCell SCF injector
- MuCell SCF metering system
- Minor software and hydraulic changes

Equipment can operate in both solid and MuCell modes.

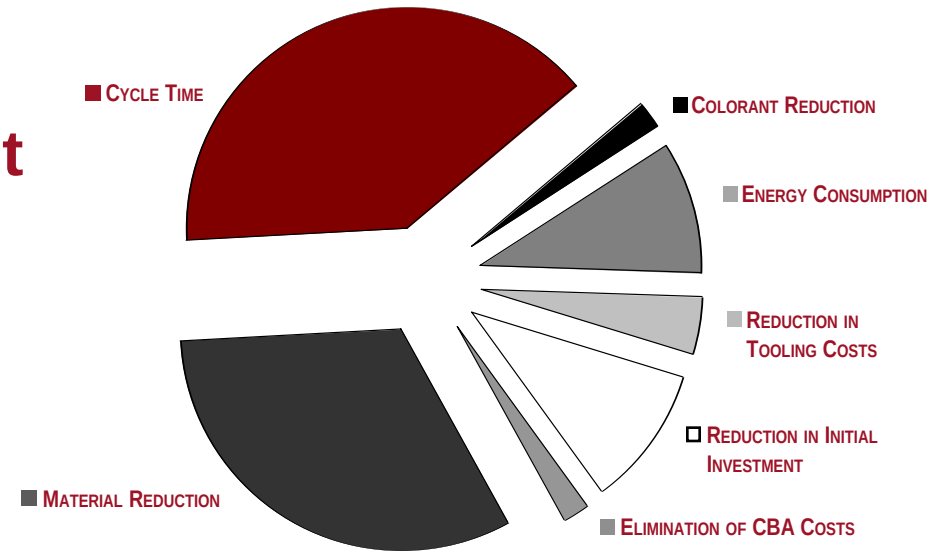
Fig 1.1

49" x 24" x 61.25"
(125cm x 61cm x 156cm)

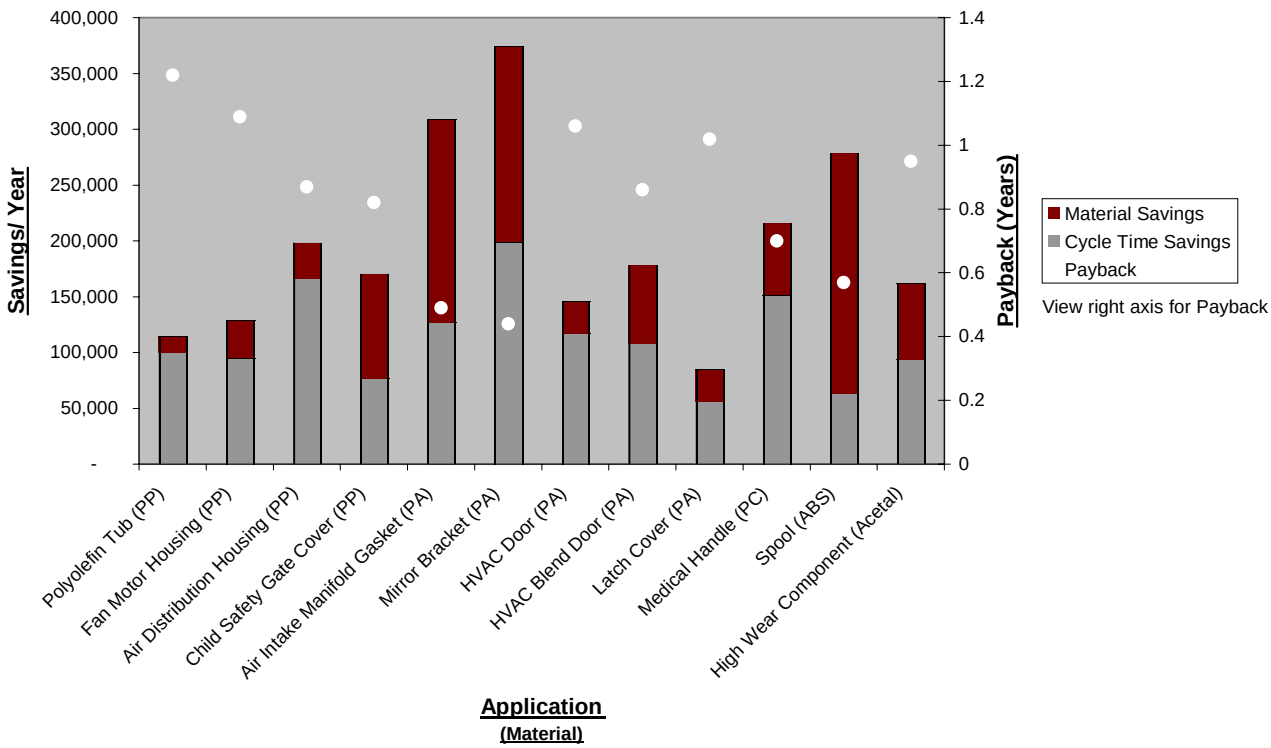
MuCell™ Technology Cost Savings

Where do potential cost savings come from?

Areas of Potential Savings



Savings and Paybacks



Implementing MuCell™ Technology

Step 1: Contact a licensed OEM injection molding equipment supplier and Trexel for hardware and license quotations.

For a list of licensed OEM machine suppliers, please refer to our website or contact us directly.

Step 2: Obtain a MuCell end user license agreement from Trexel, granting user rights to make, use and sell microcellular foam products.

- Trexel provides the MuCell license to end users on a machine-by-machine basis
- The machine license is paid annually for seven years, after which it is fully paid and irrevocable
- The annual license fee is determined by:
  - Machine size (measured in clamp tonnage)
  - Resin type (either restricted: commodity type resins such as PP, PE, and PS, or unrestricted: all resin types)

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