

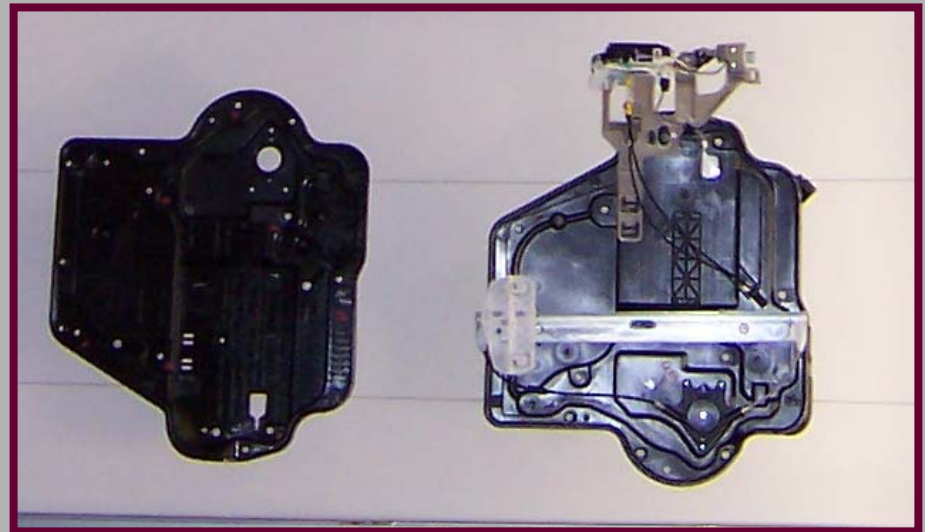
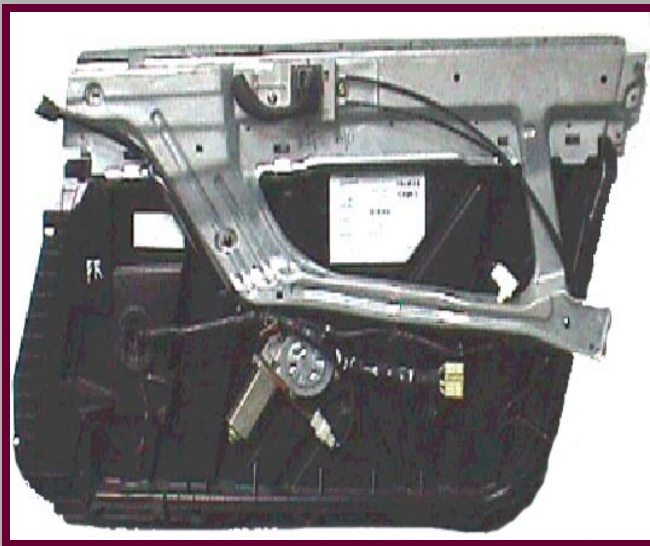
The MuCell® Process for Long Glass Fiber Reinforced Polypropylene Applications [LGFRP]

MuCell Innovation improves all fiber filled applications
(LGFRT)

David P. Bernstein
President & CEO
Trexel, Inc.

LGFRP Provides Major Advantages to Producers

- Typical target is door module (carrier, brackets)



Other Product Targets



Bumper Support



Fender Extension



Front End Support



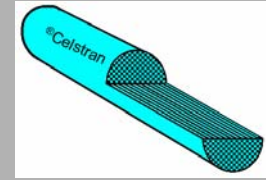
IP Substrate

LGFRP Advantages

- **Substitution for metal door modules and carriers**
 - Meets rigidity and impact requirements not achievable with standard glass fiber
- **Lighter weight than metals**
- **More opportunity for integration than metal**
- **Lower cost than metals**

Material Systems for LGFRP

- Pre-compounded material
 - Standard Injection Molding
- Compounded at the machine
 - Combination of long glass fiber PP concentrate with standard PP to reduce costs
- In Line compounding
 - Continuous feeding of special fiber roving and in line cutting and compounding system mixing with unfilled PP



Example

Comparison of Processing Systems for LGFRP

- **Standard Injection Molding**
 - Lower capital costs
 - Excessive warpage
 - Extended cycle time to reduce warpage
 - Higher materials costs
 - Use of pre-compounded or partly compounded materials

Processing Systems for LGFRP

(Cont'd)

- **In Line Compounding**
- **+ Injection Compression Molding**
 - High capital investment for twin screw extrusion system to compound material
 - Generally feeds an accumulator
 - Justifiable in High Volume programs
 - Lower material costs
 - Less warpage

IMC System



Typically requires secondary process to punch out various sections of the door module (speakers, locks, etc.)

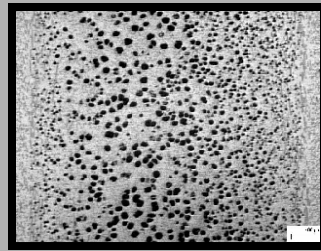
Processing Systems for LGFRP

(Cont'd)

- **Injection Compression Molding**
 - Can be done with standard injection machine or IMC System
 - Low pressure reduces warpage and cycle time
 - Increases mold complexity
 - Typically requires secondary process to punch out various sections of the door module (speakers, locks, etc.)

The MuCell® Process

The MuCell Process is based on the controlled use of gas during the injection molding cycle in its supercritical state (SCF) to create millions of micron-sized voids in otherwise solid materials made from thermoplastic polymers.



Foamed LGFRP

MuCell Molding Machine



TOSHIBA

DHC DongShin Hydraulics co



Series II SCF System

ENGEL

KRAUSSMAFFEI

ARBURG

MuCell Processes
TREXEL INC.

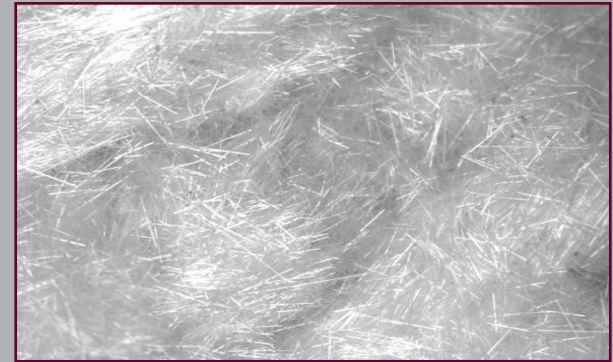
NISSEI
P

HUSKY
Keeping our customers in the lead

MuCell Technology Breakthrough

- **Original MuCell Screw Design and MuCell Process resulted in excessive breakage of glass fibers**

New MuCell screw design and new MuCell process parameters retain physical properties by reducing fiber breakage



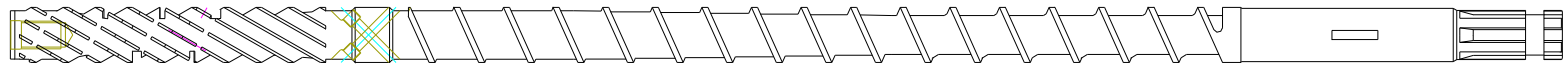
Old Trexel Screw Design
(Note short fuzzy fibers)



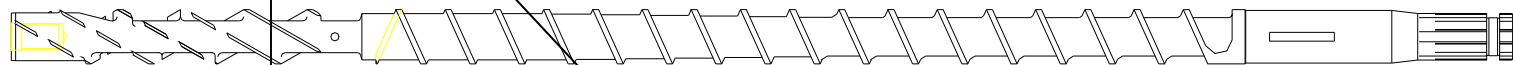
MuCell Long Glass Fiber Screw Design

- Key design changes address high shear areas of the screw:

Standard MuCell Design



LGF Design



Lower Compression Ratio

Convert Ball Check to Ring Check

Reduce Wiping and Mixing Flights

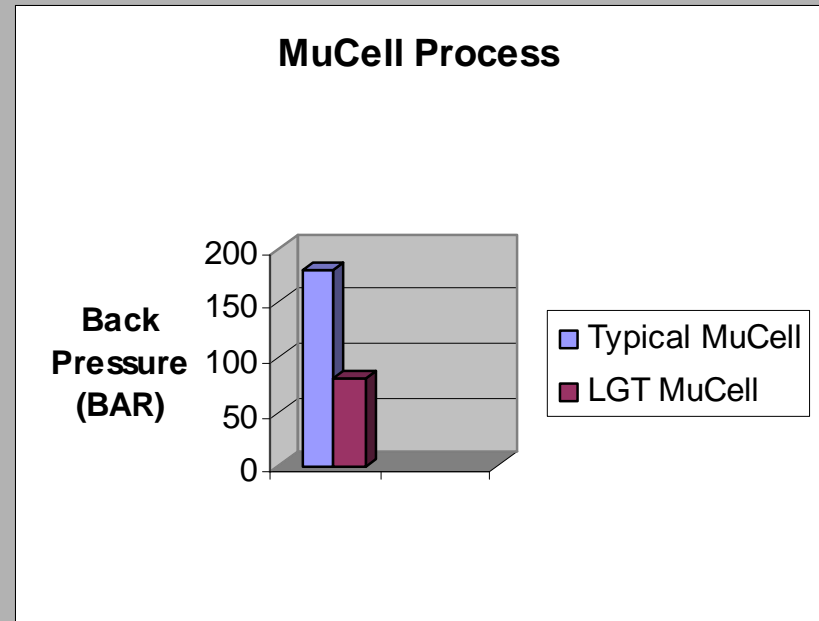
New Screw Design and new Process Parameters enable warpage reduction and weight reduction

MuCell Technology Breakthrough

- Original MuCell Process parameters resulted in excessive breakage of glass fibers

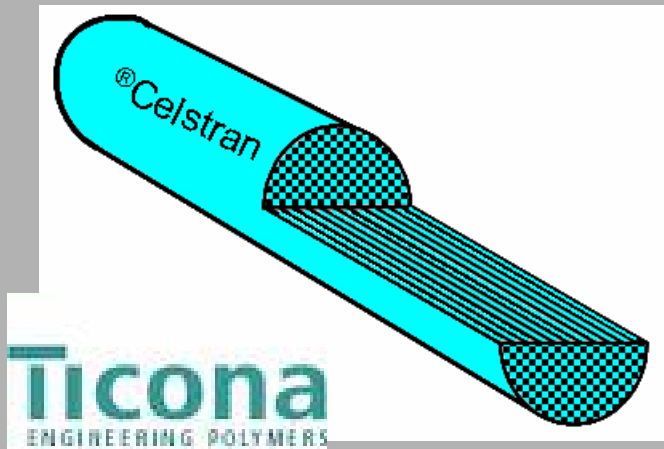
MuCell LGF Process
Parameter Changes include:

- Injection Speeds
- Screw Speeds
- ***Back Pressure Settings



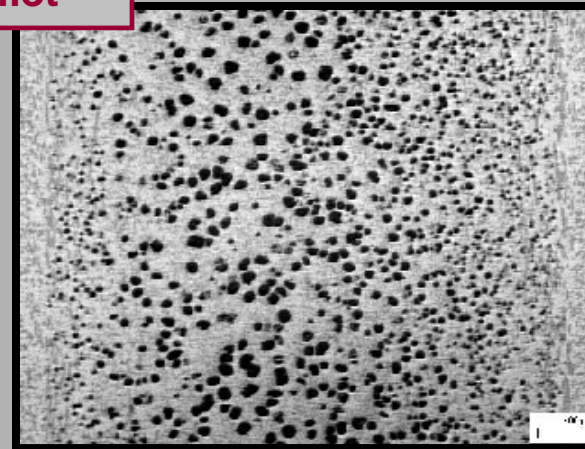
All Testing Conducted on Celstran[®] Long Glass Fiber (LGF)

- Long fiberglass length dramatically increases strength and toughness.
- Typical pellet length is about 11 mm.

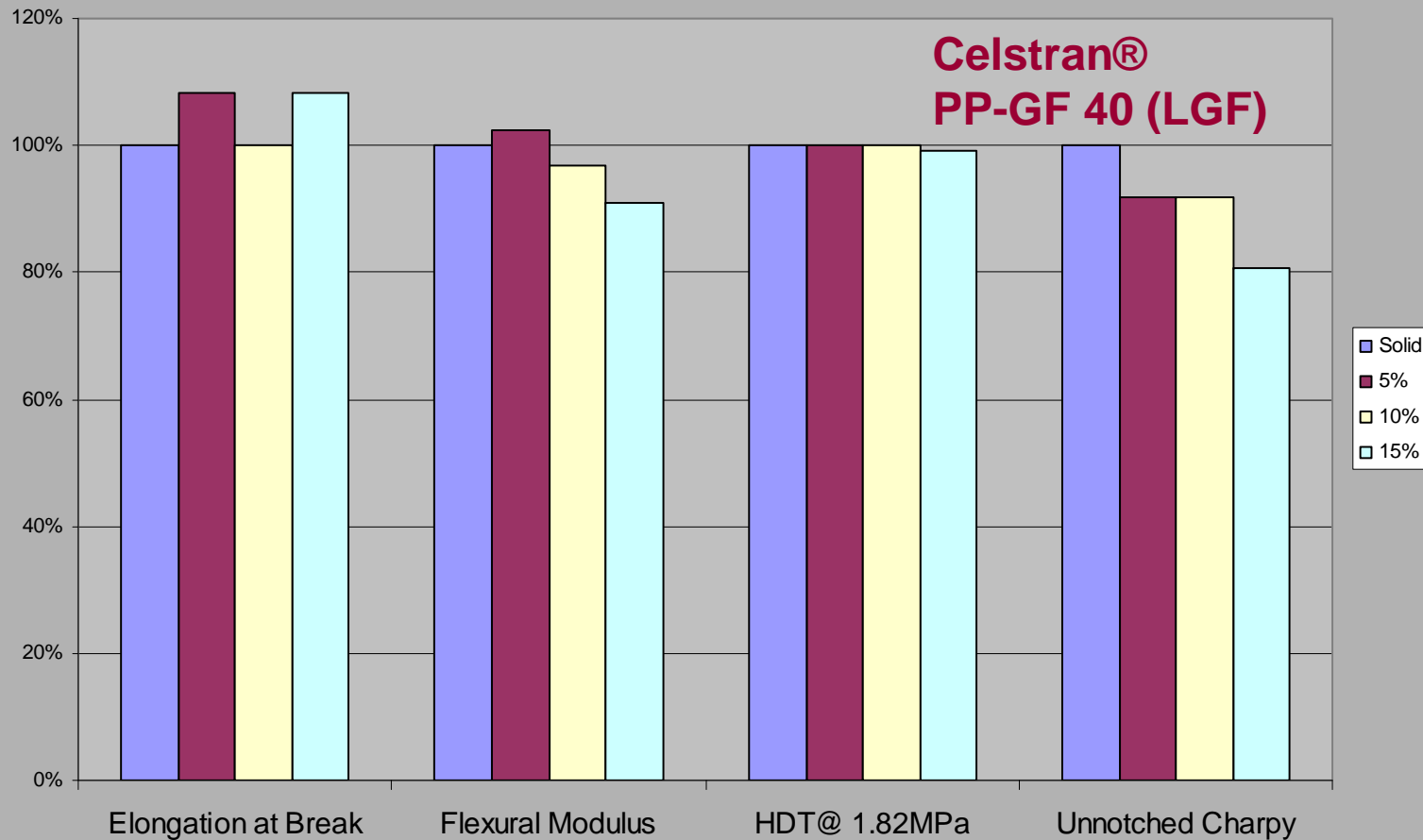


Fully impregnated molding pellet

Uniform micro-cellular structure (cell size < 50 μm)



New MuCell Screw Designs Provide Excellent Property Retention vs. Solid Molding



**40% Improvement in Drop Impact Strength
with new screw and Process**

MuCell Advantages

Standard injection molding

- Major reduction in warpage for standard injection molding
- Reduction in cycle time of >15% in standard injection molding
- Material savings 7-10% with nominal property loss (see properties)
- Reduction in clamp tonnage requirements by > 40%
- Increased cavitation on lower tonnage machines

MuCell Advantages

Injection Compression

- Open mold means higher foaming levels and greater weight reductions
 - Material savings 10-14% with nominal property loss (see properties)
- Cycle time reduction due to reduced material volume

MuCell Advantages

In Line Compounding

- **Extrusion characteristics of system favor the MuCell Process**
 - Tend to be very high volume programs
 - Continuous operation means very high output
 - High injection rates into the mold mean good cell structures
- **High output means large material savings per line**
 - 350,000-500,000 pounds per line per year of LGFRP
 - \$290,000-\$425,000 per year
- **Easy Conversion to MuCell capability**

Summary of MuCell Benefits

Economic Comparisons

Benefit	Standard Molding	Compression Molding	IMC	IMC Compression
Warpage Reduction	High (3X)	Low	High(3X)	Low
Weight Reduction	Moderate (6-10%)	High (10-14%)	Moderate	High
Cycle Time Reduction	High (15-20%)	Moderate (10%)	High	Moderate
Clamp Tonnage Reduction	High (40%)	N.A.	High	N.A.
Economic Payback	High	High	Very High	Very High

MuCell System Implementation

- **The MuCell Process can be added to either a standard injection molding system through a MMU (MuCell Upgrade); or**
- **The MuCell Process is easy to implement on most in line compounding systems with simple changes in:**
 - Front section screw components
 - Accumulator hydraulics
 - Barrel ports
- **The MuCell Process can be purchased on new factory systems**

Conclusions

- **The MuCell Process facilitates the use of LGFRP with standard molding processes by overcoming warpage and retaining a high percentage of properties.**
 - With reduced cycle time and weight
- **The MuCell Process provides remarkable economic benefits to IMC and compression molding in weight reduction because of extrusion characteristics.**
 - High Volume
 - Open Mold

Mold Trials

LGT Trials are Available on an Engel Duo Machine in York, PA

1000 Tons; 120 MM Screw



Contact Trexel, Inc. to schedule trials