Lightweighting Techniques for Thermoplastic Polymers

by Maria Rosa Contardi, Maria Teresa Scrivani

K12 Midterm conference, May 18th 2017
Mission

Proplast
private R&D centre,
representing the «actors» of polymer and composite materials and processing industry

To know more about partner companies see: http://www.proplast.it/en-us/Members/Detail
Our Premises

1998

C/O Politecnico di Torino sede di Alessandria
Academic training (Politecnico di Torino)

proplast
specialized training
创新创业

proplast
fundamental and applied research
(Politecnico di Torino)

2008

new premises
C/O Parco tecnologico - Rivalta Scrivia

proplast
technical services for SMEs
Product engineering
process engineering
material engineering
technology transfer
applied research
ecodesign
international cooperation

2013

Sedi in Provincia di Palermo
(S. Flavia e Bagherla)

proplast
fundamental and applied research
(Politecnico di Torino)
Our activities

- Technical training
- Product Engineering
- Process Engineering
- Materials Engineering
- Plastics Academy
EU collaborative research projects

**PLASTICIRCLE**

Improvement of the plastic packaging waste chain from a circular economy approach (H2020)

**FIRE-RESIST**

Developing Novel Fire-Resistant High Performance Composites (FP7)

**Phos-Istos**

Development of biophotonic device based on flexible light emitting textile dedicated to the monitoring and treatment for dermatologic diseases and carcinoma (FP7)

**multiHYBRIDS**

Innovative sensor-based processing technology of nanostructured multifunctional hybrids and composites (FP6)

**LIGHT PET**

Innovative process and solutions to reduce the weight of PET containers and boost the diffusion of the green (Life+)
National collaborative research projects

GreenFactory4Compo
Green Factory for Composites
(Regione Piemonte - Piattaforma «Smart Manufacturing»)

Veicoli urbani stradali su gomma ecologici, ergonomici, economici, sicuri ed interconnessi, per il trasporto di persone e/o merci (Ministero per lo sviluppo economico – Bando «Industria 2015»)

Sistemi e Componenti per il recupero dell'energia e l'efficienza energetica di autoveicoli (Regione Piemonte - Bando «Piattaforma Automotive»)

DIATEME
Dispositivi ad alto contenuto tecnologico per il settore biomedicale (progetto PON, “Ricerca e Competitività 2007 – 2013” Regioni Convergenza)

POLILED
Materiali polimerici per LED ad alta efficienza (Regione Piemonte - Bando «Poli Innovazione»)

WIN-STREET
Water IN: STReet design with Environmental Engineering Technologies (for urbanized areas) (Regione Piemonte - Bando «Poli Innovazione»)

FILGREEN
Studio di fattibilità di FILati a base GRafenE per l'immagazzinamento di Energia (Regione Piemonte - Bando «Poli Innovazione»)

3D Filter
Stampa 3D per miglioramento di membrane per filtrazione di gas (Regione Piemonte - Bando «Poli Innovazione»)
Training activities

• **Classes for graduated students**  
  - post University specialization degree in Polymer Science and Technology

• **Classes for high school graduates**  
  - injection molding  
  - mold maintenance  
  - CAD for plastics

• **Classes for people working in the plastics sector**  
  - more than 30 different theoretical and practical classes on plastics materials and processing technologies held every year  
  - training courses designed upon specific company needs
Seminars and conferences about new materials and new technologies

Events examples:
• Heat & Cool Technologies
• Conductive Polymers
• Technical conference on Mucell® technology
• Energy management for the plastic processing industry
• Polymers compounding
• Scientific moulding
• Fiber reinforced composites
- Tailoring of formulations vs. the final application by the means of different technologies (compounding, melt blending, reactor and solid state polymerisation)

- Explorative and feasibility studies about new polymers and additives

- Environmental sustainability:
  - biopolymers
  - polymers for green applications (photovoltaics, membranes)
  - recycling of post-consumer waste

- Development of high-performance polymeric materials:
  - flame retardant materials
  - nanocomposites
  - high stability polymers (vs. aging, weathering, stress cracking)
  - metal replacement
  - thermoplastic polymers
  - adhesive polymers
  - food packaging materials
  - conductive plastics
• Injection molding (Heat-and-cool, Roctool®, Mucell®)
• Pre-series molding
• Compounding
• Film extrusion
• Thermoforming
• Thermoplastics & thermosets composites
• Metal/ceramic injection molding (MIM, CIM)
Product and process engineering

- Development and optimization of new products
- Design and manufacturing of pilot molds
- Rapid prototyping

FEM structural simulations

- Static/dynamic non linear analysis
- Impact analysis
- Modal/vibrations analysis

Process simulations

- Thermoplastics injection molding simulations
- Thermosetting injection molding simulations
- Blow molding/thermoforming simulations
- Thermal analysis
Lightweighting in injection molding: the MuCell® technology

The two key elements of MuCell technology:

1. Lowering of the viscosity of thermoplastic resins by controlled feeding of gas (either N\textsubscript{2} or CO\textsubscript{2}) into the melt

2. Creation of a microcellular structure in the part core by gas expansion in the cavity

Proplast demo line
Installed on Engel injection machine - 180 tons, 55 mm screw
100-500 grams typical part size
CO\textsubscript{2} or nitrogen
Lightweighting in injection molding: the MuCell® technology

Dissolving SCF into the melt

- Screw flights break-up SCF stream
- Mixing flights cause SCF to divide into smaller bubbles and then dissolve

Inject SCF

Diffusion Complete

A single phase solution is created by injecting the SCF (super critical fluid) into the thermoplastic melt during screw recovering.
Lightweighting in injection molding: the MuCell® technology

MuCell line typical layout
Lightweighting in injection molding: the MuCell® technology

Typical ‘sandwich’ structure of MuCell parts:

Compact skin - Foamed core - Compact skin
Lightweighting in injection molding: the MuCell® technology

Foaming occurs during injection into the mold

- Low pressure in the mold cause SCF to form cells
- Cells grow until the material freezes or the mold cavity is full
Lightweighting in injection molding: the MuCell® Process

MuCell benefits

• Cavity
  foaming process instead of post pressure
  lower clamping force

• Injection unit
  lower viscosity, leading to better filling behavior and lower pressures
  better filling behavior
  new part design and gate positioning possible
  potential temperature decrease

• Part
  integral structure
  lower part weight
  less warpage
  no sinkmarks
Lightweighting in injection molding: the MuCell® Process

Productivity improvement: overall cycle time reduction

Δ_T depends on material type, part design and mould cooling
Lightweighting in injection molding: the MuCell® Process

Productivity improvement: reduction of hydraulic pressure

Solid

Peak $p_c = 1045$ bar

MuCell®

Peak $p_c = 448$ bar

57% reduction in peak cavity pressure

Due to viscosity reduction, less resin volume, no pack & hold pressure

Longer tool life

Data Com Connector, PBT 30% GF
Case History #1: Cam Cover

Achieved benefits:

- 30% reduced machine size (350 instead of 500 ton for conventional molding)
- Improved cycle times, allowing for simultaneous production and assembly process
- Lighter part
- Improved flatness
Case History #2: Dual fan shroud

Achieved benefits

- Typical weight reduction 7-10%
- Machine size reduction from 1000 tons to 500 tons
- Cycle time savings of 25-40%
- 200% improvement in fatigue resistance
- Cpk values improved by 50%
Roctool Processes

Advanced Heat & Cool technology for Composite and Plastic Injection molding by using electromagnetic induction allows to heat a mould in a matter of seconds.

Roctool benefits

- Optimal surface quality: glossy or mat, no visible weld lines
- Thickness reduction is possible
- Mechanical properties increased
- Pressure reduction
- High temperature molding is possible
- Very fast heating of the mold
Promix Solutions

- In extrusion processes temperature differences in the melt are generated by the plasticizing process in the screw, melt pumps, screen changers and even by empty pipe sections.

- Melt Blenders such as Promix blenders efficiently equalize temperature variations over the whole cross section.

Equal melt temperature and velocity are key for high quality extruded products.
In an empty pipe polymer melts will form a laminar profile

Promix melt blenders destroy the laminar profile and create a very effective cross mixing resulting in:

- Equal velocity
- Equal temperature
- Narrow residence time distribution
- Excellent melt homogeneity
Processing: light weight extrusion - Promix
Processing: light weight extrusion - Promix

Effective temperature homogenization
Benefits of Promix Mixing Nozzles

- Effective avoidance of color streaks
- Equalized color depth / better color appearance
- Saving of 20 – 30% master batch (= 1’000 to >10’000 Euro savings / year)
- No brilliant spots due to homogenization of temperature profile
- Reduced cycle time due to optimized processing parameters
- Better tolerances
- Improved processing of recyclates (usability of more recyclate or better product quality)
- Improved balancing of hot runner systems

3-4 shots of non colored PP can purge out the blue masterbatch
Promix foaming system is a patented process for the production of extruded microcellular foams.

Main features:

- Significant weight and cost reductions
- High quality microcellular foams
- Density reductions of 10 to >70%
- Use of the environmental friendly blowing fluids CO2 und N2
- No licenses
**Processing: light weight extrusion - Promix**

Promix foam system with fluid injection and static mixing and cooling modules

**Promix foam extrusion systems** are installed downstream of the existing extruder barrel and consist of components for fluid injection, homogenization and cooling. The blowing fluid is provided by a high precision gas dosing station.
Advantages of physical vs. chemical foaming:

- Fast amortization of investment, usually < 1 year
- Higher process stability, better cell structure
- Lower foam densities possible
- No health risks due to chemical residues
- Production waste is 100% recyclable
- Improved cell structure and smoother surface in foam extrusion, thanks to mixers
Installation example

600 kg/h PP sandwich board line, foam density 500 kg/m3

- Feed block / die
- Melt cooler
- Static mixing module
- Fluid injection module
Case History #1: dairy products packaging

PS foam sheet
Thermoform application for dairy products
Substitution of chemical foaming

Result:
- Reduction of foam density
- Better process stability
- Better foam structure

Promix Solutions
Case History #2: PP foam core pipes

PP foam sheet
Automotive application
Density 210kg/m³ (13lb/ft³)

Result:
• Reduction of foam density
Thanks for your attention

**Proplast** - Consorzio per la promozione della cultura plastica
Strada Savonesa, 9 – 15057 Rivalta Scrivia – AL
Tel: +39 0131 1859711
[proplast@proplast.it](mailto:proplast@proplast.it)
[www.proplast.it](http://www.proplast.it)