Temperature Control in Manufacturing Self Reinforced Polymers (SRP’s)

“A smart way to keep cool”

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Outline

1. Who is Regloplas
2. European Project ‘Esprit’
3. Temperature Control Developments in ‘Esprit’
4. Dynamic Heating / Cooling System: Vario
5. Applications / Customer Benefit
1. Who is Regloplas

- Family owned private company
- 50+ years of experience
- 70 employees in Switzerland and > 200 worldwide
- Pioneers in temperature control
- Wide range of TCU’s and Chillers from –8°C up to 350°C
- Representatives in over 50 countries
- > 7000 TCU’s per year
Regloplas customers

GM

CHRYSLER

HITACHI

Inspire the Next

Toyota

GET THE FEELING.

TOSHIBA

HUSKY

HONSEL

Red Bull

RYOBI

DELPHI

Driving Tomorrow’s Technology

VISTAKON

DuPont Canada

STILEXO

DIE CASTING IN ALUMINUM

Aluminium Laufen AG

Ford

SG

HONDA

HARTING

BOSCH

Nestlé

fischer

GEBERIT

Tyco Electronics

Williams F1 Team
2. European Project ‘Esprit’

- Goal: Resource-Efficient Self-Reinforced Plastic Materials and Processing
The Project Partners

The research leading to these results has received funding from the European Community’s Seventh Framework Programme NMP-2007-2.4.1 under grant agreement 214355
The Esprit Project Overview

- **Focus: Self Reinforced Polymer (SRP) composites**
  - Fiber and matrix of the same thermoplastic polymer
  - Lighter than glass reinforced materials
  - Better impact resistance
  - More easily recyclable (no mineral fibers to extract)

- **EC supported project, 3.5 years, finished March 2012**

- **Aim: to produce flowable SRP, reduce plastics usage**

- **Reason: to overcome the manufacturing limitations of current sheet SRP materials**

- **Molding method: Injection molding, Compression molding**
Techniques employed

- Reduce melt temperature of matrix and/or increase temperature stability of reinforcement.
  - Gives a bigger process window, between the fiber and matrix materials, allowing parts to be molded without degrading fiber reinforcement.

- Fiber /matrix combining techniques
  - Commingling fibres + pultrusion, melt impregnation of matrix into reinforcement. Pellets.

- Selective heating of the matrix
  - To heat just the matrix, not the reinforcement. Microwave and induction heating.

- Modified process machinery
  - Alternative heating methods, tooling modifications, modified pultrusion lines. Control the temperatures.

- Injection and Compression molding
  - Aim to heat and mould the SRP pellets without degradation of the reinforcement.
Highlights

- **SRP families tested:**
  - srPA (Nylon), srPET (Polyester), srPO (Polypropylene). srPET proved to be the most candidate, offering a decent process window and good property improvements.

- **Greatly improved additive dispersion achieved:**
  - (Carbon Nano Tubes in PP), vital for good heating by electromagnetic methods. Implications in other compounding applications.

- **Successful injection and compression molding**
  - srPET – 30% improvement in tensile modulus for injection moulded samples
  - PET/PP – high impact resistance (65kJ/m² compared to 9kJ/m² base PP) injection molded samples
The Ultimate Aim

- **Case Studies**
  - Automotive parts
  - Sports goods
  - Lightweight panels
  - Defence
  - Luggage
  - Aerospace

- Anything that can be injection or compression molded in PP, PET or PA could potentially benefit from this technology
3. Temperature Control Developments in ‘Esprit’:

- **Dynamic Heating / Cooling System**
  - Very relevant to Self Reinforced Polymer (SRP) composite systems
  - SRPs can be heated in-tool, using textiles made from yarns of mixed matrix and reinforcement fibers
  - Requires a quick heating cycle, a controlled holding temperature and a quick cooling cycle
Dynamic Heating / Cooling System

- For the Esprit flowable compounds, the temperature control of the mould tool is essential:
  - As the material leaves the injection mold barrel it travels into the tool at high pressure with the possibility of generating uncontrolled, shear-induced heating
  - For non-SRP materials this is not a problem
  - For SRP materials extra heat can lead to reinforcement fiber degradation
  - Result: accurate, quick, efficient heating and cooling is required
  - Dynamic heating systems can supply that by using hot and cold circuits simultaneously
Dynamic Heating / Cooling System

- For the Esprit Project:
  - Used in conjunction with appropriately designed tools, dynamic heating systems provide dynamic tool control, allowing the processing of heat-sensitive materials such as SRP’s.

Drawings courtesy of Promolding
Dynamic Heating / Cooling System

- For the natural fibre reinforced products the temperature control of the mould tool is essential:
  - Natural fibre reinforced thermoplastics (e.g. flax or jute fibres in PP or PET) can be moulded from textiles, direct in the tool.
  - The fabric is loaded into the tool, then heated and cooled under pressure to form it. This gives greater conformability.
  - Speed of heating/cooling is critical to cycle time and mechanical properties.
  - Accuracy of heating is critical to achieve matrix melt without damaging the natural fibres.
  - Dynamic heating systems can supply both these requirements by using hot and cold circuits simultaneously.
Dynamic Heating / Cooling System

- Using flax/PP biocomposites:
  - Used in conjunction with appropriately designed tools, dynamic heating systems provide dynamic tool control, allowing the processing of heat-sensitive materials such as natural fibres.

Photos courtesy of Composites Evolution
4. Dynamic Heating / Cooling System: Vario

- Temperature Control Unit
- Hot circuit
- Cold circuit
- Hot circuit
- Cold circuit

Graph showing temperature (T) over time (t) with cycle time (t_{Cycle})
Dynamic Heating / Cooling System: Vario

Temperature Control Unit

Cold circuit

mold / cavity

\( T \) [°C]

\( t_{Cycle} \) [s]

\( t \) [s]

冷电路

模具 / 腔室

温度控制单元

冷电路
Dynamic Heating / Cooling System: Vario

- Water units up to 180°C
- Hot oil units up to 300°C
- Standard dual or single units
- Turn key solution including high temperature switching valves and ‘energy battery’
  - Cycle time reduction
  - Improve surfaces
  - Eliminate weld lines
  - Fill difficult cavities faster
Dynamic Heating / Cooling System: Vario

- Unique energy saving concept
- Storage of hot and cold energy
- Sizing according to application
- Automatic filling procedure
- Compact design
  - Faster cycle times possible
  - Optimized energy balance

Vario ‘energy battery’

Hot circuit
Cold circuit
Temperature Control Unit

‘Energy battery’
Dynamic Heating / Cooling System: Vario

- Energy Battery
Dynamic Heating / Cooling System: Vario

Part A

- Oil Temperature Control Unit
- Dual unit
- 70 °C – 280 °C
- Cooling and heating process (Variotherm)
  - Reduction of cycle time
  - Online monitoring
Dynamic Heating / Cooling System: Vario

- Pressurized Water Control Unit
- 2 Single units
- 60 °C – 170 °C
- Cooling and heating process (Variotherm)

- Reduction of cycle time
- Improved filling and surface
- Environmentally friendly
5. Applications: Vario

- Weld lines
- Optical lenses
- Parts with thin walls
- Shiny surfaces
Applications: Vario

Composites/SRP’s

Micromolding

Dual material components
### Customer benefit

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<tr>
<th>ROI</th>
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<tbody>
<tr>
<td>✓ Quality improvement</td>
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<tr>
<td>✓ Quality consistency</td>
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<tr>
<td>✓ Cycle time optimization</td>
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</table>
| ✓ Lower running costs  
  (energy, life time die, oil,…) |
| ✓ Environmentally friendly |

💧 **Less cost per part**
Q+A’s

Thanks for your attention!

“A smart way to keep cool”