Induction Heating Simulation
with Autodesk® Moldflow®

Benelux Autodesk® Moldflow® User Meeting
- Creation of the Company: 2000
- Technology Provider for Plastic Injection and Compression
- Most advanced Heat and Cool technology in the industry
- Engineering Team 100% focused on Heat & Cool solutions
- Facilities in Europe, Asia and North America
RocTool Offices

France
Headquarters & Demo Center

Taiwan
Office & Demo Center

USA
RocTool Inc. Office & Demo Centers

Japan
Office & Demo Center

Italy
Demo Center

Germany
RocTool GmbH Office & Demo Center
Markets

- Aerospace
- Consumer Products
- Electronics
- Automotive
- Sport and Leisure
- Energy
- Cosmetics
3iTech® – Overview

- High speed heating of the tool surface with integrated induction network
- Cooling with water lines
- Complete mold temperature control with easy interface (thermocouples)
- Process designed for standard steels
- Full automatic mode compatible with all press machines
3iTech® – Primary Technology

Close up of the inductor cavity:

Induced Currents

Injected Currents

Magnetic Fields

Molding Surface

Mold in Magnetic Steel
- Example 1.2343 (H11)
- Electric resistivity \( \rho_r : 40 \, \Omega \cdot m \)
- Relative permeability \( \mu_r : 55 \)
- Thermal conductivity \( k : 27 \, W/m.K \)

Thermal Diffusion

Insulating Layers (1 or 2)

Inductor (copper)
A complete process integration

- Patents and License
- Generator Packages
- Engineering and FEA
- Tool Design Support
- Development & Production Support

Complete Induction Heat & Cool Package includes:
- Engineering / Simulation & Full Analysis
- Generator Package with Peripherals
- License and know how transfer
- Installation, Start Up & Complete Training
Performance Benchmark

<table>
<thead>
<tr>
<th></th>
<th>Heating Speed</th>
<th>Temperature</th>
<th>Energy Cost</th>
<th>Process Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction Heating</td>
<td>Up to 25°C/sec</td>
<td>Up to 400°C</td>
<td>Low to Medium</td>
<td>Extended</td>
</tr>
<tr>
<td>Flow Processes*</td>
<td>Up to 10°C/sec</td>
<td>Up to 180°C</td>
<td>Medium High</td>
<td>Limited</td>
</tr>
<tr>
<td>(Steam; Pressurized water)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Heater*</td>
<td>Up to 5°C/sec</td>
<td>Up to 300°C</td>
<td>Very High</td>
<td>Limited</td>
</tr>
</tbody>
</table>

*MATERIAL AND DESIGN (2010) 382–395*

Research of thermal response simulation and mold structure optimization for rapid heat cycle molding processes, respectively, with steam heating and electric heating - Guilong Wang, Guoqun Zhao, Huiping Li, Yanjin Guan
RocTool Engineering
An Overall Control of the Process

Electromagnetic Analysis
Thermal Analysis
Thermomechanical Analysis
Flow Analysis
Surface Quality

Elimination of Visible Weld Lines
Surface Quality

Combination of High and Low Gloss Possible
Flow Improvement

Flow Improvement and Thin Wall Capabilities

BT ADSL Hub with thin wall for LED
Application Examples: Interior Automotive
Application Examples: Interior Automotive

- **Renault Zoe** – Central Cluster
- **Citroen C4 Cactus** – Interior Trim
- **BMW 7 Series** – Rear Entertainment System
- **Mercedes-Benz S-Class** – Rear Entertainment System
Application Examples: Electronics

Electronic devices
Electronic Accessories
Laptop A and D covers
Smartphones Battery covers and Body parts
High Definition Plastics Evolution

Laser Texturing
- Eliminate Secondary Operation
- Unique Design Possibilities
- New Aesthetics
- Brand Recognition (patterns)

Surface Oriented Resins
- Color / Particels
- Durability
- Scratch Resistance
- Chemical Resistance
- Additional Features (haptics)

Induction Heat
- Top Surface Quality
- Defect Reduction or Elimination
- Thinner Walls

Injection Molding
- Design Functionality
- Productivity
- Chemical Resistance
- Additional Features (haptics)
RocTool Combined with Laser Etching

with RocTool Technology: Better Replication of Mold and Low Gloss Improvement

<table>
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<tr>
<th>Case</th>
<th>VDI*</th>
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<td>Mold</td>
<td>22</td>
<td>1.43</td>
<td>24</td>
<td>1.85</td>
<td>27</td>
<td>2.47</td>
</tr>
<tr>
<td>Plastic Part</td>
<td>17</td>
<td>56%</td>
<td>19</td>
<td>54%</td>
<td>22</td>
<td>54%</td>
</tr>
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Material: PC
Mold Temperature: **80°C/176°F**

*VDI 3400 (CH)

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<tr>
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<td>21</td>
<td>85%</td>
<td>23</td>
<td>92%</td>
<td>26</td>
<td>93%</td>
</tr>
</tbody>
</table>

Material: PC
Mold Temperature: **160°C/320°F**

*VDI 3400 (CH)
- RocTool Heat & Cool Technology
- Top Surface Quality
- Combined with Laser Texturing
- OEM Proprietary Pattern
MuCell® and RocTool Combination

MuCell® For:
- Lightweighting
- Material savings
- Dimensional Stability

RocTool For:
- Top Surface Quality
- Process Improvement
- Part Overall Improvement
Unique Aesthetic

Light diffraction textures: Replication of 3D textures
Induction Heating Simulation with Autodesk® Moldflow® Insight

Real induction simulation developed by Autodesk® Moldflow® on top of the Cool (FEM) module in the Moldflow Insight 2016 release

- Dual Domain and 3D mesh models
- Available in Moldflow Insight Premium and Ultimate
- The analysis demonstrates the impact on the final product
Model Components

- Part
- Induction Coil
- Air gap
- Cooling channels
Process parameters

Apply High/Low potential terminal conditions to the induction coils
Electro-magnetic results

Magnetic flux density

Induced current

Joule heating
Joule Heating over time
Transient Mold Temperature
Transient Mold Temperature Cavity Side
Transient Part Mold Temperature Cavity Side
Transient Mold Temperature Core Side
Transient Part Mold Temperature Core Side
Temperature vs time at 3 points

Induction heating starts at 36s
Filling
Welding lines

Because the mold temperature is hot and above the glass transition temperature, the welding line will not be visible.

In the same way the aspect in front of the 2 nozzles is satisfying.
Packing

Compared to CIM, packing lasts for a longer time because the cooling rate is slower.

- High temperature
- Good pressure transmission
- No freezing
Warpage
- Performed an Induction Heating Simulation and use results as injection trials input

- Compare simulation to experimental data
  - Tool equipped with RJG sensors: temperature and pressure

Plastic part: 150x80x1.8 mm

Resin: PC Makrolon® AL2447 from Covestro
Tool equipment

- Tool equipped with 2 surface pressure sensors, 1 temperature (RJG) & 1 RocTool Thermocouple to control process

- Surface sensor pressure (RJG) mounted in an insert
- Surface sensor temperature (RJG) mounted in an insert
- Thermocouple RocTool (to control process) mounted in an insert

RJG software – Machine interface
Tool design

- **CAD model**
  - Cavity and Core side
    - Mold block
    - Induction coil
    - Air gap
    - Coolant circuit

- **Moldflow model**
  - CAD import
  - Assign properties & materials
  - Meshing mold & part
  - Implement boundary conditions
  - Implement process settings:
    - Cool FEM input
    - Induction input
    - Injection input
  - Run Induction simulation
Process parameters

- Assign Property & Material

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<tr>
<th>Name</th>
<th>Property</th>
<th>Material</th>
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<tbody>
<tr>
<td>Mold block</td>
<td>Mold Block (3D)</td>
<td>Steel</td>
</tr>
<tr>
<td>Cavity &amp; Core</td>
<td>Mold insert (3D)</td>
<td>Steel</td>
</tr>
<tr>
<td>Air gap</td>
<td>Mold insert (3D)</td>
<td>Air</td>
</tr>
<tr>
<td>Induction coil</td>
<td>Induction coil (3D)</td>
<td>Copper</td>
</tr>
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</table>

- Process cycle description

Electrical & Thermal data are essential for each component

Time = 0s to 7s: 3itech heating (during previous part extraction)

Time = 11s: mold closing
Time = 13s: part filling

Time = 48s: mold opening + part ejection - end on the thermal cycle

Cycle time implemented directly in process setting & on induction coil for Heating control
Insert-cavity interface Temperature, Transient

- Cavity side
- Core side

GIF animation
Temperature, mold-cavity interface

Temperature, mold-cavity interface (transient): XY Plot

Time [s]
Correlation

Cavity interface temperature evolution during cycle process

Cavity interface temperature (°C)

Time cycle (second)

Trial data
Simu_STEEL GAP_48KHz_425amp
Thank you for your attention.

Please visit our website RocTool.com