SM1730-P: Simulation of Injection Compression and Compression Molding (Part I)

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Key learning objectives

At the end of this class, you will be able to:

- Understand the basic process/principles
  - Injection Compression Molding (ICM)
  - Compression Molding (CM)
- Understand the ICM and CM capabilities
  - Autodesk Simulation Moldflow Insight
  - Focus on 3D Simulation.
- Present Validation Cases
  - Injection Compression Molding (ICM)
  - Compression Molding (CM)
- SM2790-P: Study of Molded-in Stresses and Warpage Behavior in Injection Compression Molded Parts
  - 4:00 – 5:30PM Today
Injection Compression Molding (ICM)
ICM – The Process

Initial Injection Stage

Compression Stage
ICM - Advantages

- Longer Flow Lengths
- Low Molded in Stress
- Surface Finish
  - Reduced Sink
- Lower Clamp Tonnage
- Faster Molding Cycle
- Improved Dimensional Tolerances
ICM - Disadvantages

- Increase Machine Cost
- Increased Tool Costs
ICM – Typical Applications

Optics
Communication
Automotive

ICM - Simulation

- 3D Analysis Sequences

Thermoplastics Injection-Compression

- Fill
- Fill + Pack
- Fill + Pack + Warp
- Cool
- Cool + Fill
- Cool + Fill + Pack
- Cool + Fill + Pack + Warp
- Cool (FEM)
- Cool (FEM) + Fill
- Cool (FEM) + Fill + Pack
- Cool (FEM) + Fill + Pack + Warp

Reactive Injection-Compression Molding

- Fill + Pack
- Fill + Pack + Warp
- Cool (FEM)
- Cool (FEM) + Fill + Pack
- Cool (FEM) + Fill + Pack + Warp

Thermoplastics Injection-Compression Overmolding

- Fill
- Fill + Pack
- Fill + Pack + Overmolding Fill
- Fill + Pack + Overmolding Fill + Overmolding Pack
- Fill + Pack + Overmolding Fill + Overmolding Pack + Warp
ICM – Simulation - Modelling
ICM – Simulation - Inputs

### Process Settings Wizard - Compression Settings - Page 2 of 3

- **Compression direction**: +Z
- **Press open distance**: 0.4 mm (0.5000)
- **Press compression starts**: At the end of packing
- **Press compression time**: 1 s (0.1200)
- **Press speed cap**: 1 mm/s (0.1000)
- **Press compression force cap**: 100 tonne (0.70002)

<table>
<thead>
<tr>
<th>Distance (mm [0:5000])</th>
<th>Press compression speed (mm/s [0:1000])</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>0.4</td>
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</tbody>
</table>

- **Switch to press force control**: Only when the press force reaches compression force cap
- **Compression force after switch to press force control**: Absolute value

[Advanced options]
ICM – Simulation - Results

- Volumetric Shrinkage is lower in the cavity with compression
Compression Molding (CM)
Compression molding is one of the oldest known molding processes
CM – Advantages

- **Part Quality**
  - Strength
  - Fewer knit lines on final product
  - Internal stress and warping are minimized
  - Dimensional accuracy & stability is excellent

- **Cost**
  - Low tooling costs
  - Little "throw away"

- **Large parts**
  - Thick sections and large parts are practical.
  - Lower molding pressures/Press tonnage
CM – Disadvantages

- Low Cost effectiveness
  - Usually need a Press Operator
- Product consistency
  - Charge Weight/Position/Shape must be tightly controlled
- Part Design Limitations
  - Not suitable for fragile mold features, or small holds
  - Uneven parting lines present a mold design problem
  - High impact composites make flash control & removal difficult.
  - The depth of the molded holds is limited to 2 or 3 times their diameter
CM – Typical Applications

- Electrical
- Automotive Panels
  Frames
  Seat Components
- Compression Molding
  + Composites
3D Analysis Sequences

- Thermoplastics Compression Molding
  - Fill
  - Fill + Pack
  - Fill + Pack + Warp
  - Cool
  - Cool + Fill
  - Cool + Fill + Pack
  - Cool + Fill + Pack + Warp
  - Cool (FEM)
  - Cool (FEM) + Fill
  - Cool (FEM) + Fill + Pack
  - Cool (FEM) + Fill + Pack + Warp

- Reactive Compression Molding
  - Fill + Pack
  - Fill + Pack + Wire Sweep
  - Fill + Pack + Warp
  - Cool (FEM)
  - Cool (FEM) + Fill + Pack
  - Cool (FEM) + Fill + Pack + Wire Sweep
  - Cool (FEM) + Fill + Pack + Warp

- Thermoplastics Compression Overmolding
  - Fill + Pack
  - Fill + Pack + Overmolding
  - Fill + Pack + Overmolding Fill + Overmolding Pack
  - Fill + Pack + Overmolding Fill + Overmolding Pack + Warp
CM – Simulation – Modelling
CM – Simulation – Initial Charge

- Initial Charge (3D)
- Tetrahedral Elements
  - Mesh Density similar to Cavity
- Any Regular/Irregular Shape
  - No Voids
- Separate Cavity and Initial Charge
CM – Simulation – Initial Charge
CM – Initial Charge
CM – Initial Charge
CM – Initial Charge
CM – Simulation – Initial Charge
CM – Simulation – Initial Charge

- Initial Fibre Orientation
CM – Simulation - Inputs

Process Settings Wizard - Compression Settings - Page 3 of 3

- Compression direction: Z
- Pure compression press open distance option: Automatic
- Press compression time: 8 s (0-1200)
- Press speed cap: 38.1001 mm/s (0-10000)
- Press compression force cap: 149.632 kN (0-70000)
- Press compression speed vs distance (compression is along z-axis):

<table>
<thead>
<tr>
<th>Distance mm (0:5000)</th>
<th>Press compression speed mm/s (0:1000)</th>
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<tbody>
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<tr>
<td>2</td>
<td>25.4</td>
</tr>
<tr>
<td>3</td>
<td>38.1</td>
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</tbody>
</table>

- Switch to press force control:
  - By % nodes filled: at 100 % (0-100)
  - Compression force after switch to press force control:
    - Relative to the value at switch over: Edit values...

Advanced options...
CM – Simulation - Results
CM – Simulation - Results
CM – Simulation - Results

Press speed: XY Plot

Average volumetric shrinkage
Time = 110.0 [s]

Scale (50 mm)
ICM and CM – What Next?

- We need to be guided by you?
  - Process Variants
  - + Composites
  - + Overmolding