Casting Simulation Technology

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Casting materials

Market Overview [Mio tons]

<table>
<thead>
<tr>
<th>Material</th>
<th>Density [kg/m³]</th>
<th>Cost/tonne [$]</th>
<th>Relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Steel</td>
<td>7820</td>
<td>550</td>
<td>1</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>7225</td>
<td>830</td>
<td>1,51</td>
</tr>
<tr>
<td>Aluminium/alloys</td>
<td>2700</td>
<td>2220</td>
<td>4,0</td>
</tr>
<tr>
<td>Titanium /alloys</td>
<td>4500</td>
<td>17 000</td>
<td>30,9</td>
</tr>
</tbody>
</table>

From Modern Casting
“2010 world census casting production”
Need for Casting Simulation

- Sophisticated materials and geometries call for advanced casting processes
- Requirements for simulation
  - Mold filling with solidification
  - Defect Prediction
  - Design tool to help the casting vendor to evaluate the filling and solidification process

Casting Processes
- Gravity Die or Sand Casting
- Tilt - Casting
- Centrifugal Casting
- Low Pressure, Counter-Pressure-Casting
- High Pressure Die Casting
- Precision Casting
- Lost Foam
- Continuous Casting
- Vacuum Casting
Strategic Partnership

- **Best of both worlds**
  - Provide state of the art of casting simulation solution by combining the engineering experience of two companies which have a long-standing track record in providing CAE solutions and casting processes for over 25 years
  - Established casting solution STAR-Cast
• First released in 2009
• Dedicated design and engineering tool for the casting engineer
  • Process orientated GUI

• Core -Capabilities
  • Multiphase - liquid, solid and gaseous phases
  • Resolution of the molten flow and filling front
  • Model the molten material in its semi-solid state
  • Dedicated material database
  • Uses STAR-CCM+ state of the art meshing technology

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- Precision Casting
Goal of STAR-Cast development

• Further reduce the development time for new or complex casting processes

• Broaden the applicability of the casting solution
  • More materials
  • More processes

• Flow, thermal and solidification simulation in one tool
The Process

- Easy to learn
- Quickly adaptable to simulation needs

**Geometry**
- Any given CAD data
- 3D-CAD Modeller

**Mesh**
- Fluid /Solid Interfaces
- Appropriate meshing models

**Physics**
- Adapt to simulation goal
- Expandable

**Post processing**
- Transient Postprocessing
- Criteria functions, defect analysis

**Filling**
- VOF
- Isothermal- gating design
- Thermal - cooling/ solidification
- Particles/ erosion

**Solidification**
- Progress of Solidification
- Influence on flow
- Misruns and cold shut

**Motion**
- Piston Motion
- Tilting
- Rotation
Challenges - Meshing

- Multi region problem
  - Complex Geometry
  - Fluid Cavity
  - Surrounding Air
  - Different solids (mold, cooling iron ..)

.. Calls for a strong and powerful meshing solution:

- Easy surface repair
- Multi region Volume meshing
- Volume meshing with integrated prism layer generation
- Quick volumetric refinement for thin walled castings
Solidification

- **Mushy Zone Model**
  - Transition from liquid to solid leads to partially solidified areas
  - Takes into account the material specific fraction solid curve
- **Slurry Zone**
  - Grains of solidified material form areas of solidifying material hindering the flow
- **Flow Stop**
  - Complete stop of flow in solidified areas
A dedicated Material Database is available in STAR-Cast, pooling all relevant material information for the casting engineer. The database includes:

- Material comparison
- Temperature depended
- Recommended datasets
- Fully documented
- Database expandable
  - Import or change datasets
- Explicit usage rights
  - Confidentiality ensured
Defect prediction: Criteria Functions

- Used to deduce additional information about the solidification process
  - Based on temporal and spatial temperature distribution
- Gather Temperature gradients, cooling rates and local solidification times
- Compute criteria functions, such as Niyama or G/v criterion
- Estimate microstructure characteristics
Investment Casting: Shell generation

- For precision casting
  - Ceramic mold is created by dipping a wax model into a ceramic based slurry
  - Ceramic slurry dries and builds the mold for the casting
  - The wax is removed in an autoclave
Investment Casting: Shell generation

• **Workflow**
  – Start with your wax model
  – Define the shelling parameters

• **Example: Turbine Blade**
  – Automated process
  – 4 mm shell thickness
  – Computational time ~250 s for shell generation and meshing
  – Conformal mesh between fluid and mold
  – ~345,000 cells
Sand Casting: Phase selective wall porosity

- Phase selective wall porosities for VOF- Phases
  - Capture the venting effect of a porous mold (i.e. Sand)
Looking ahead

• Provide more accuracy, robustness and ease of use for a wider range of casting processes

• Include further solidification models
  – Ductile Iron, Grey Iron
  – Composite castings

• Visit Access at their booth to get in touch with our experts and learn what can already be done today

• Casting Webinar
  – Updating you on our casting capabilities