Manufacturing Simulation for the Casting Industry with STAR-Cast
Agenda

- Manufacturing Simulation
- Casting
- STAR-Cast
  - Application coverage
- Outlook
Simulation for Manufacturing

- Simulation widely used for
  - Research
  - Product Design
    - Verification
      - Thermal
      - Efficiency
      - Safety

- Increased interest in manufacturing processes
  - Process simulation
  - Tool Design
# Manufacturing of Castings

## Aspects of Casting Manufacturing

### Materials
- Non Ferrous alloys
  - Aluminum
  - Nickel
  - Titanium
  - …
- Ferrous alloys
  - Steel
  - Ductile/Grey Iron
  - …

### Casting Processes
- Die Casting
  - Tilt
  - Low/High Pressure-Casting
  - Gravity
- Precision Casting
  - Centrifugal
  - Bridgeman
  - Continuous Casting
  - Sand Casting

### Manufacturing:
- Casting
- Filling and Solidification
- Defect distribution
- Structural integrity
- Accuracy
- Tools
  - Cooling
  - Design
  - Longevity

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**Overall goal:** Increase the quality of the casting and minimize production costs
Casting Simulations

Objectives

- Where Casting Simulation aids manufacturing
- Sensitivity analyses for process parameters
- Geometrical parameter studies
- Defect Elimination
- Objectives where Casting Simulation aids manufacturing
- Enhancement and conservation of raw materials
- Reduce number of trial runs

Defect Elimination

- Geometrical parameter studies
- Enhancement and conservation of raw materials
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- Sensitivity analyses for process parameters
- Objectives where Casting Simulation aids manufacturing

Enhancement and conservation of raw materials

- Geometrical parameter studies
- Defect Elimination
- Objectives where Casting Simulation aids manufacturing
- Sensitivity analyses for process parameters
- Reduce number of trial runs
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
STAR - Cast

- Dedicated tool for Casting Simulations
- Key Features:
  - Multiphase Filling & Solidification
  - Criteria Functions for Defect Prediction
  - Material Database
  - Shell mold generation

Processes

- Permanent Mold
  - Tilt—Casting
  - Die Casting
    - Low/High Pressure
    - Gravity
- Lost Mold
  - Sand Casting
  - Precision Casting
    - Bridgeman
    - Gravity
    - Centrifugal
• Latest release (with STAR-CCM+ v8.02) as an Add-on to STAR-CCM+

• From CAD to Post Processing in one GUI

• Add all the benefits of having STAR-CCM+ in the background
  – Expand STAR-Cast’s application coverage
  – State of the art Meshing and Solver technology
    • Parts Based Meshing
    – Leverage STAR-CCM+’s streamlined workflow

• New Release of STAR-Cast every 4 months
STAR- Cast: Multi Phase Simulation

• Fully Transient Simulation
• Simultaneous solving for flow and energy:
  • Multiphase: Volume of Fluid (VOF)
    • Resolution of the molten flow and filling front
    • Model phase change
  • Conjugate Heat Transfer
    • Convection, Conduction, Radiation
    • Across multiple fluids and solids
A dedicated Material Database is available in STAR-Cast, pooling all relevant material information for the casting engineer.

- Material comparison
- Temperature depended
- Recommended datasets
- Fully documented
- Import or change datasets
- Explicit usage rights
Enthalpy Melting Solidification Model
- Enthalpy formulation to track solid portion of the metal phase

Mushy / Slurry Zone for metal alloys
- Large solidification intervals
- Growing net of dendrites impede flow

Flow Stop Model
- Complete stop of flow in solidified areas
STAR-Cast: Defect Prediction

- Aim is to provide additional information on the quality and structure of the casting
  - Shrinkage
  - Macro/ Micro Porosities
  - Primary/Secondary Dendrite Arm Spacing

- Available Models
  - Criteria Functions
  - Macro Porosity Model

Criteria Functions
- Liquid Residence Time
- Isotherm Speed
- Mean Cooling Rate
- Solidification Velocity
- G/v Criterion
- Niyama Criterion
- Primary Dendrite Arm Spacing
- Secondary Dendrite Arm Spacing

Ref: Access, STAR-Cast
Casting Processes

Die Casting
• Low/High Pressure Die Casting
• Tilt Die Casting
• Gravity Die Casting

Sand Casting

Investment Casting
• Gravity Casting
• Centrifugal Casting
• Bridgeman Process

Other Processes
• Continuous Casting
• Composite Casting
• Pouring Simulation

STAR-Cast application range
Die Casting – Tilt Casting

- Tilting of the entire system
  - Die, Cast Part, Cores, ...
  - Tilting curve applied via Rigid Body Motion
  - Track air bubbles

90 deg turn in 10 s
Die Casting - LPDC

- Time depended pressure profile pushes the melt into the die
- Improper process parameters like pressure profile or die temperature leads to porosities

Several casting cycles necessary to achieve steady state temperature profile
Sand Casting

- Large and complex castings
- Porous mold
  - Porosity is crucial for the mold filling
- Incorporate feeder, cooling irons, filters
- Mold filling important for the overall quality of the casting
  - Accurately capture the pouring of the melt
Challenges in Investment Casting

- Thin-walled components with designs at the limit of producibility
- New materials
- Shell molds/ wrappings

- Shell Mold Generator

Automatic shell mold generation

Courtesy of Access
**Investment Casting**

- **Lost mold process**
  - Investment mold is porous
    - Back pressure influences filling

- **Bridgeman process**
  - Estimate proper heater location and power
  - Part removal via Rigid Body Motion

- **Gravity**

- **Centrifugal**
  - Rotating crucible
  - Stationary crucible
STAR-Cast and beyond

- Bringing STAR-Cast and STAR-CCM+ closer together leads to synergy effects

- Extended application coverage
  - Optimization with OPTIMATE
  - Detailed Die Cooling analysis
  - Pouring Optimization
STAR-Cast and OPTIMATE

- Leverage STAR-Cast’s capability with OPTIMATE for design optimization
- Example
  - Design exploration with STAR-Cast and OPTIMATE/Sherpa
  - Find sensitivities between Shape/ Die temperatures and feeding capabilities
    - Solidification time (max)
    - Solidification front (minimum area)
Pouring Optimization with STAR-Cast

- Pouring optimization
  - Reduce misruns
  - Increase yield
    - Skull reduction
  - Use STAR-Cast (VOF + Overset mesh) to find optimized pouring curve
  - Variation in rotational speed, pouring height and position
Outlook

• The new Casting User Interface in v8.04
  – To be used as a stand alone or parallel to the simulation tree

• Benefits
  – High degree of automation
  – Short learning curve
  – Driven by the casting process
    • Add additional physics as required
THANK YOU!!

• We invite to visit our best practice session on Wednesday from 10:30 to 12:30 in the Royal Palm Ballroom 2

• Live Demo’s to highlight key features of casting simulations with STAR-Cast
• Sneak a peek at the new Casting User Interface