Optimizing Your Casting Design and Cost

Presented by
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Presentation Overview

- Why Castings?
- Types of Casting Costs
- Casting Design Process: Serial vs. Concurrent
- Autonomous Design Optimization
- Benefits of Successful Designs
- Q & A
Why Castings?

- Flexibility to apply material directly to load-bearing areas
- Ability to develop highly complex functional structures
- Cost reduction through part consolidation
- Weight and cost reduction through shape optimization
- Durability and fatigue strength enhancements through elimination of welds
Superior Durability of Castings

Source: “Ductile Iron Data for Design Engineers” Sorelmetal, 1998
Cost of Quality – Scrapped Castings

- For metal casters, by far the most potent drivers of profitability are pricing and scrap:

“It’s been said the true and largely hidden cost of poor quality is **THREE TIMES the sales value of scrap castings**…

Dan Marcus “A More Nuanced View” – AFS Modern Castings, August 2014, p. 55
Cost of Quality - Casting Warranty Claims

The cost of managing the claim are high vs returning the casting:

- The value-added cost (machining, finishing, etc.)
- Cost of disassembly after installation
- Part replacement
- Shipping costs
- Costs of lost time
- Costs of lost labor and “peripheral damage”
Typical Casting Costs (for major casting processes)

\[
\frac{\text{Cost}}{\text{Part}} = \frac{C_t}{N} + V C_M + \frac{C_H t_{cycle}}{Y} + \frac{C_D}{N}
\]

- Total non-recurring tooling costs ($)
- Material costs ($/in^3)
- Machining costs ($/hr)
- Y, process yield (useable parts/N)
- Total development costs ($)

Casting Design Process: Serial

One Single Design Iteration!

Serial (Traditional) Design Process

Required inputs
- CAD model
- Fully machined model
- Casting alloy
- Process, i.e. green sand, etc.

Set up single simulation

Calculations

Result Analysis

Time Consuming = Additional Iterations Extend Lead Times to Production!

NO

Design meets defined criteria?

YES

Approve/Release Final Design!
Casting Design Process: Concurrent

- Form Cross Functional Design Team
- Define Design Objectives
- Create the Initial Design
- Refine/Approve Initial Design
- Refine and Optimize

Refine and Optimize – Autonomously

Result Analysis

Set up optimization

Software will autonomously

Allow more iterations under one set up
Consider multiple designs & process variability
Find better solutions

- Define input ranges
- Define objectives
- Change required inputs
- Run simulations
- Monitor progress and adjust accordingly
Refine and Optimize – Two Approaches

Autonomous Design of Experiments (DoE)
- User chooses designs to simulate
- Software changes inputs

Autonomous Optimization
- Software chooses designs to simulate
- Software monitors progress towards goals

VS.

User selects which designs to run
Optimization selects which designs to run
Case-Study: Pump Rotor Housing
Case-Study: Pump Rotor Housing

DOE Optimization - 35 Different Machine Stock Scenarios

Point 1

Point 2
Simulate Many – Assess Once: Statistical Evaluation of Results

Design Variables:
- Point 1 Z-value: 63 to 93 mm
- Point 2 Z-value: 80 to 90 mm

Optional:
- Initial casting temperature

35 Designs solved in 3 hours 15 minutes of computer time!

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Objectives

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Simulate Many – Assess Once: Statistical Evaluation of the Design Space

Reduce Shrink Porosity

Minimize Machine Stock

Design #34
Summary – Autonomous Design Optimization

- Concurrent design and castability analysis - address the entire casting design process from CAD to quoting to rigging design to casting process setup
- Autonomous DOE and Optimization simulations consider design and process ranges and are easy to set up and fast to run
- Timely feedback for the design and foundry engineers to evaluate quality and set acceptance criteria
- Timely feedback for the procurement/SQA engineers to evaluate and reduce:
  - Potential costs based on the complexity of the part and process
  - Potential problem areas that may affect quality and increase frequency of inspection and costs
Design Application – Heavy Truck Subframe

Honorable Mention in the Casting of the Year 2014

Benefits:
- Reduced weight by 28%
- Reduced number of components from 79 to 1
- Eliminated 136 fasteners

Source: American Foundry Society
Design Application – Double Disc Ripper Mount

Benefits:

- Reduced costs by 25%
- Improved strength (fatigue)
- Improved dimensional stability and alignment during assembly

Source: AFS Modern Castings – October 2014
Thank You!

Q & A