Why do we need TECHNOLOGY?

Challenges:

- Customer demands
  - Higher Quality and Performance
  - Lower price
  - Faster delivery

- Legislation
  - “OSHA & EPA”

- Human Resources
  - Lack of qualified foundry personnel (Engineers + Shop Floor)
  - Lack of casting design knowledge at customers
Why do we need TECHNOLOGY?

- To meet customer demands...
  - we need utilize (new) technology to deliver castings at the desired quality level
  - at the lowest possible cost
  - on time
  - every time
- There is no time for trial and error
- Castings need to meet quality requirements over the entire process window
- Process needs to be in control to provide consistent process window
Why do we need TECHNOLOGY?

- To meet legislation demands…
  - we need TECHNOLOGY to make castings without
    - Silica dust
    - Cancerous compounds
    - Hurting/killing people

![Image of a cleanroom with workers]
Why do we need TECHNOLOGY?

- To meet human resource restrictions…
  - we need remaining workforce to become more efficient (productive)
  - we need to automate the casting process
  - we need to eliminate casting design restrictions
  - we need to improve communication between designers and foundries
  - we need to embrace “Industry 4.0”
Industry 4.0 facilitates the vision and execution of a "Smart Factory". Industry 4.0 or the fourth industrial revolution is a collective term embracing a number of contemporary automation, data exchange and manufacturing technologies.
What is INDUSTRY 4.0? [Wikipedia]

- There are six design principles in Industry 4.0.
  - **Interoperability**: the ability of cyber-physical systems (i.e. workpiece carriers, assembly stations and products), humans and Smart Factories to connect and communicate with each other via the Internet of Things and the Internet of Services
  - **Virtualization**: a virtual copy of the Smart Factory which is created by linking sensor data (from monitoring physical processes) with virtual plant models and simulation models
  - **Decentralization**: the ability of cyber-physical systems within Smart Factories to make decisions on their own
  - **Real-Time Capability**: the capability to collect and analyse data and provide the derived insights immediately
  - **Service Orientation**: offering of services (of cyber-physical systems, humans or Smart Factories) via the Internet of Services
  - **Modularity**: flexible adaptation of Smart Factories to changing requirements by replacing or expanding individual modules
In other words…TECHNOLOGY…

…needs to get us from here

…to here
…available today to address these challenges

- “No-Pattern Molding”:
  - Sand Mold “Cutting”
  - 3D printing of molds and cores

- Both reduce product development time
- Both provide easier design changes
- Both eliminate/reduce design restrictions
- Both might work with alternative mold materials and binders
- Both run independently from personnel
...available today to address these challenges

- Automation and Robots
- Assure process consistency
- Take over monotonous work
- Take over dangerous work
- Don’t need to be protected by OSHA
- Run independently from personnel
TECHNOLOGY

…available today to address these challenges

- Autonomous Optimization of Casting Designs and Processes
What is Autonomous Optimization?

- Autonomous – adjective  \au\cdot ton\cdot o\cdot mous\  
  ...acting separately or functioning independently

Example: Autonomous driving
What is Autonomous Optimization?

Optimization: noun op·ti·mi·za·tion \ˌäp-tə-mə-ˈzā-shən\  
an act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible

Example: optimizing casting quality
Traditional Use of Casting Process Simulation

1. **Required inputs**
   - CAD model

2. **Process Parameters**
   - Pouring temperature
   - Pouring time
   - Shakeout time
   - Etc.

**Set up simulation**

**Calculations**

**Result analysis**

**Time consuming = fewer simulations**

**Success?**

- yes
- no

**Make pattern**
Using Autonomous Optimization

**Required inputs**

1. Average air entrapment during filling (%)

**Set up optimization**

- Define input variables
- Define input ranges
- Define goals or objectives

**Software will autonomously:**

1. Schedule simulations
2. Change required inputs
3. Run simulations

1. Reduce time spent on set up
2. Find better solutions
3. Consider process variability

**CAD model**

- **Weak Correlation**
- **Strong Correlation**
Autonomous Optimization

- You Setup One
  - Define Variables
  - Define Objectives:
    - Maximize Quality
    - Minimize Cost
Autonomous Optimization

It Simulates Many by itself…
Autonomous Optimization

You Access All At Once

Porosity

Microporosity

Yield

Design 97
Design 117
Design 158
Design 94
Autonomous Optimization

More designs = better solution

More designs = better insight
Autonomous Optimization

- Decouples Engineering Time from Simulation Time
  - Increases efficiency of engineers
- Provides Process Understanding Faster
  - Increases knowledge and efficiency of engineers
- Assures Casting Quality over Entire Process Window
  - Reduces costs and increase customer satisfaction
- Fulfills Customer demands
  - Higher Quality and Performance
  - Lower price
  - Faster delivery
Autonomous Optimization

No Simulation

Simulation

Autonomous Optimization
Also “Autonomous”...

Traditional Molding

Mold Cutting and 3D Printing
Also “Autonomous”…

Traditional Shop Floor

Automation and Robots