“What’s around the corner?”
“What’s around the corner?”
“What’s around the corner?”
GLOBAL TONNAGE NOW STANDS AT 104.3 MILLION TONS

- China 49%
- India 11%
- USA 9%
- Germany 5%
- Japan 5%

Figures from Modern Castings Dec 2017.
GLOBAL INDUSTRY (Million Tons)

1. China 47.2
   12th for Efficiency

2. India 11.4
   8th for Efficiency

3. USA 9.4
   2nd for Efficiency

4. Japan 5.2
   7th for Efficiency

5. Germany 5.2
   1st for Efficiency

6. Russia 3.9
   4th for Efficiency

7. Korea 2.6
   5th for Efficiency

8. Mexico 2.6
   6th for Efficiency

9. Brazil 2.1
   9th for Efficiency

10. Italia 2.1
    11th for Efficiency

11. Turkey 1.9
    10th for Efficiency

Figures from Modern castings Dec 2017.
Efficiency is tonnage / No of plants
GLOBAL INDUSTRY

Automotive Industry Impact

- More than half of castings produced are for the automotive industry
- This will increase with electrification
- Increasing customer demand for comfort, technology and performance
- Cars need bigger engines, bigger fuel tanks and stiffer chassis all adding weight
- Casting Industry meets weight reduction challenge with:
  * material substitution
  * thinner walls
  * converting fabrications to castings
GLOBAL INDUSTRY

Europe

- Low GDP Growth
- High Unemployment (Italy 13% & 43% of Youth)
- High Energy Costs
- EU Commission Influences
- Recognizes need for:
  - Industrial Renaissance
  - Solidify manufacturing base to provide growth and employment
  - The centrality of manufacturing & competitive integration
COUNTRY SPECIFICS

- 9,000 Foundries will be closed or merged due to program to push for high productivity & profitability as well as greater focus on quality
- New Government initiatives for development and growth in the sector
- Heavily influenced by the 13th 5-year plan
- Industry will have access to support for the achievement of improvements in 9 key areas
COUNTRY SPECIFICs

➢ 11.4 Million Tons produced in 2016
➢ Of which 9.1 Million Tons Ferrous castings
➢ 2016 has 4500 foundries significantly down in number since 2010
➢ During same time 45% Growth in tonnage output
➢ New Governmental influences assisting industry such as re-use of energy subsidy
➢ Review worth $18 Billion (only 15% is export)
➢ Expectations for doubling of output in next 5 years.

“What’s around the corner?”
COUNTRY SPECIFICS

➢ 2.91 Million Tons produced in 2017
➢ Of which 1.8 Million Tonnes Ferrous castings
➢ 2017 has 800 foundries, 600 of which are nationally owned
➢ 72.7% of its production is directed to the automotive sector
➢ 42.5% is for domestic consumption.
➢ Since 2009 there has been a reduction in the number of small & medium size foundries
➢ Since 2012, over $ 700 Million USD has been invested in automotive component foundries.
➢ The increased production of these new plants has moved above Brazil and Korea in total tons produced
COUNTRY SPECIFICS

USA
- 9.4 M T produced by 1960 foundries €32 B
- Additional 2.6 M T Mexico and .65 M T Canada
- 2008 – 2010 falling output due to off shoring and high energy costs
- 2010 – 2016 recovering output but still below the 2008 figure
- Currently very optimistic with high growth forecasts due to:
  * low energy costs
  * high productivity
  * reduced shipping costs
  * trend toward re-shoring

THE TRUMP EFFECT
“What’s around the corner?”
What is Industry 4.0

“What’s around the corner?”
“What’s around the corner?”
It’s happening now!

What in your life is connected now?

- Cell Phone
- Coffee Maker
- Washing Machine
- Alarm System
- Car/Truck
- Watch
- Refrigerator
- Doorbell
- Alexa
- Garage Door

“What’s around the corner?”
Internet of Things (IoT) Connected Devices installed worldwide from 2015 to 2025 (in billions)

“What’s around the corner?”
So what does this mean for the Foundry?

“What’s around the corner?”
“What’s around the corner?”

Customer orders Casting

Order Enters Foundry System

System controls supply chain and production planning

Molding Scheduled

Sand Chemicals ordered

Maintenance

Production starts

Production Office

All areas of the Foundry work autonomously to Mold, Cast, Fettle and Machine Casting

Finished Casting Delivered to Customer
“With less time spent doing mundane work and by eliminating guesswork, it is easy to see the efficiency gains that are possible.

In Germany, industry is talking about average productivity gains of 5-8 percent with some sectors seeing up to 20 per cent and the potential of Industry 4.0 adding over $14 trillion to the global economy in the next 15 years.”
The Benefits

- Preventative Maintenance
- Real Time monitoring
- Production information
- Remote access from anywhere
- Remote connection with Equipment Supplier

Small Steps....

- 4.0 can be expensive and time consuming
- Look at small steps
- Plan your route integrating relevant technologies as you see fit
- What will have biggest impact/lowest cost

“What’s around the corner?”
“What’s around the corner?”
Additive Manufacturing

- 1 in 2.5 Metal Casters have used 3D printed sand.
- Over 10 new 3D Sand Printers have been installed in the last 2 years in the US.
- AFS offers 5 training modules pertaining 3D printed sand.
- Kimura in Shelbyville, Indiana, is the first US 100% 3D Printed Foundry.
- Proven print speeds now up to 4.7 ft.³/hour (up from 2.86)

“What’s around the corner?”
Additive Manufacturing

• BMW has launched IDAM, (Industrialization and Digitization of Additive Manufacturing) for Automotive Series Processes and plans 50,000 3D Printed Components/Yr.
• Continental AG opened an 8,000 m³ Additive Manufacturing Center
• Boeing is starting to replace certain castings with Laser Sintered Thermoplastic components.
• APWORKS (Germany) has created the first metal printed 3D motorcycle.

“What’s around the corner?”
Additive Manufacturing

- As Laser Sintering patents expire, new lower cost machines are now entering the market.
- As technology advances, certifications and testing will continue to open doors.

“What’s around the corner?”
Additive Manufacturing

Your Next Pattern Shop?

“What’s around the corner?”
Subtractive Manufacturing

Robotic Machining of Pattern-Less Molds

• A low-cost alternative for pattern-less casting

“What’s around the corner?”
Case Studies

How milling can be used in Pattern-less Casting:
1. Mold milling vs. 3D printing molds
2. Mold milling with 3D printed cores
3. Hybrid – mold milling with 3D printed mold inserts

“What’s around the corner?”
Case Study 1

The following is assumed:

• The volume of the molds are the same
• The material cost is the same
• Tool wear is insignificant compared to the cost of machine
depreciation times run time
• Differences in design time and setup time is not considered

For this case study, the following is known:

• The 3D sand printer currently costs 5 times that of the robotic
  milling machine
• The time to produce 3D printed molds is 3 times that of mold
  milling
• The %xy is 70% to produce both the cope and drag

“What’s around the corner?”
3D Printing and Mold Milling Introduction

3D Printing:

Job box size: 1800 x 1000 x 700 mm
Build speed: 60,000-85,000 cm³/h

Approximate installed investment: $1,500,000 USD

RSM-2 Mold Milling:

Cell consists of:
- Kuka KR-90, 6-axis industrial robot
- 12 tool automatic tool changer
- Base for clamping sand blocks up to 2000 x 2000 x 1000 mm
- Programming: Mastercam/Robotmaster

Approximate installed investment: $375,000 USD

“What’s around the corner?”
Cost Examples

3D print all components or mill the molds?

Variables Considered:

\[ mc = \text{material cost (cost unit} \times \text{mm}^3) \]
\[ \%xy = \text{percentage of xy printing area (mm}^2) \]
\[ t = \text{machine run time (hours)} \]
\[ V = \text{enveloping volume size (mm}^3) \]
\[ D = \text{machine depreciation (}\frac{\text{cost unit}}{\text{hour}}\text{)} \]
\[ tw = \text{expendable tooling cost (cost unit)} \]

\[
3D \text{ print cost} = (mc \times V) + [D \times t \times \%xy] \tag{1}
\]

\[
\text{Robot mill cost} = (mc \times V) + [(D \times t) + tw] \tag{2}
\]

“What’s around the corner?”
Cost Examples

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Quantity</th>
<th>Price</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Toolpath Development (NRE)</td>
<td>4</td>
<td>$27.59</td>
<td>$110.36</td>
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<td>Milling</td>
<td>Robo-Mill ($22.29/hr @ 4 hr/mold set)</td>
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<td>$89.16</td>
<td>$713.28</td>
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<tr>
<td>Set-Up</td>
<td>Tooling/Mold Set-Up ($24.36/hr @ 2 hr/mold set)</td>
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<td>$48.76</td>
<td>$390.08</td>
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<tr>
<td>Tooling</td>
<td>Consumable Tooling</td>
<td>8</td>
<td>$135.46</td>
<td>$1,083.60</td>
</tr>
</tbody>
</table>

36" x 48" x 8" Cope / 6" Drag Sand Block Mold Sets to be supplied by Customer

| 3DSP | Printed Mold Set                       | 8        | $2,420.00 | $19,360.00 |

* Quote is valid for 30 days.
* Standard delivery two weeks from receipt of geometry and Purchase Order (PO).
* Multiple box quantities and specialty sands or blends may increase lead times.
* Defective product due to supplied geometry will be the responsibility of the customer.
* Price does not include shipping or packaging

Subtotal: $2,297.40

Return Credit: $ -
TAX Rate %: 0.0%
TAX @ 10 %: $ -
Total: $2,297.40

“What’s around the corner?”
Cost Examples

<table>
<thead>
<tr>
<th>Code</th>
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<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option #1: Hybrid Option (RoboMill/3DSP): 5.25 DI Nozzle (single cavity)</td>
<td>3</td>
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<td></td>
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<tr>
<td>Design: Toolpath Development - Non-Recurring Expense (NRE) (hrs)</td>
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<td>$27.59</td>
<td>$165.54</td>
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<td>Total Price Hybrid Nozzle (w/ NRE):</td>
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<td>Option #2: 3DSP Option: 5.25 DI Nozzle / 5.25 DI Bonnet (single cavity)</td>
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<tr>
<td>Sand</td>
<td>5.25 DI Nozzle: 3DSP Cope/Drag/Core mold set (per mold set)</td>
<td>2</td>
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<td>Option #2 Total:</td>
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<td>$5,413.72</td>
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</table>

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* Price does not include shipping or packaging

“What’s around the corner?”
### Cost Examples

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<tr>
<td></td>
<td><strong>Option #1: Hybrid (RoboMill/3DSP)</strong></td>
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<tr>
<td>Design</td>
<td>Toolpath Development - Non-Recurring Expense (NRE) (hrs)</td>
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<td>$27.50</td>
<td>$165.54</td>
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<td>Sand Blank: 48&quot; x 60&quot; x 12&quot; (per mold set)</td>
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<td>Robo-Mill (hr/mold set)</td>
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<td>Tooling/Mold Set-Up (hr/mold set)</td>
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**What’s around the corner?**

Milled Cope

Milled Drag

Printed Cores
"What's around the corner?"
Cost Examples

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<td><strong>Option #1: Hybrid (Robomill/3DSP)</strong></td>
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<tr>
<td>Design</td>
<td>Toolpath Development - Non-Recurring Expense (NRE) (hrs)</td>
<td>6</td>
<td>$27.59</td>
<td>$165.54</td>
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<td>3DSP Mold Inserts &amp; Core (per mold set)</td>
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</table>

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“What's around the corner?”

Milled Cope

Milled Drag

Printed Cores & Inserts
“What’s around the corner?”
THANK YOU!

Wil Tinker
Tinker Omega Sinto, LLC
wtinker@tinkeromega.com

“What’s around the corner?”