Smart 3D Printing

Agenda

• Who We Are
• Building Engagement & Knowledge
• Use Cases
Smart 3D Printing

Agenda

• Who We Are
Caterpillar is the world’s leading manufacturer of construction and mining equipment, diesel and natural gas engines, industrial gas turbines and diesel-electric locomotives.
Additive Manufacturing at Caterpillar Inc.

- 1990 – Rapid Prototyping Lab
  - SLA, LOM, SLS, FDM, Metal
- 2009 – Design Groups
  - FDM
- 2013 – Innovation Group
- 2014 to present
  - Additive Manufacturing Group
  - Additive Manufacturing Factory
  - Nomadic Printer Program
  - SLA, SLS, FDM, DMLS, ink jet
Smart 3D Printing

Agenda

• Who We Are

• Building Engagement & Knowledge
Building Engagement & Knowledge

- Deployment Acceleration
- Additive Manufacturing Factory
- Nomadic Printers
Deployment Acceleration

Catalyst Group – bring in expertise
- RCWT Additive Manufacturing Summit
- Mentor and coach engineers

Nomadic Printer Program
- Expose employees to 3D printing with a printer at their facility

Accelerate adoption of additive in product groups
- Product Group ownership
- A&I Additive Manufacturing Group enablers

Additive Manufacturing Factory
- Source of supply
- First parts delivered
Additive Manufacturing Factory

- Machines available to produce production intent parts
- A tool to help with technical expertise and be a production source
- Status
  - Estimated completion: October 2015
Nomadic Printers

• Expose employees to the potential of 3DP by having a printer at their facility to use and experiment with
  – Different…
    • Processes
    • Suppliers
    • Materials
    • Software
• Duration
  – 6 months
  – 6 locations
Nomad Program Feedback

• Much innovation spurred by having a system
• Ink jet printers too much for our beginners…
• Initial glee until…‘sticker shock’ when re-ordering material

Lessons Learned

• Internal website for sharing, i.e. ask questions, share failures
• Start small; move up the technology ladder
• Dispel the notion that “it’s nice, but we need metal”
• Culture change: Cost of 3DP vs. realization of benefits
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Use Cases

• Design Verification / Display
• Gauging
• Manufacturing Aids
• Casting Aids
• Production
1/12<sup>TH</sup> Scale Dragline Bucket
Undercarriage Roller Comparison

DESIGN VERIFICATION

3D Printed Assemblies to show design differences
Half Scale Hammer

Saved $10K to $15K tooling cost
Tip/Adapter Assembly - Trade Show

Tip/ Adapter Assembly
Adapter truncated to make a base
Field Gauges

Stacked assembly of four field gages

Compactor Tip gage - Slider bar is lowered to meet tip surface, indicating worn percentage

$50 vs. $600/1 Week
CMM – Plastic Link and Fixture

36 Track Links of various sizes

- Machine Setup
- Safety Improvement
- CMM Programming

Savings = $160,000
Molds – Silicone Masking

MANUFACTURING AIDS

Molds made from scrap steel:
- Heavy
- Sharp edges
- Not reliable

Savings in repair = $27,000/yr
Snap Gauge Handles

MANUFACTURING AIDS
Piston Ring Removal Tool
Rocker Arm Assembly Fixtures

Savings:
- $10,000 design and fabrication cost
- 8 weeks lead time
On returned cores the part numbers are usually worn away, so a profiling tool is required for identification.

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Printed</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$18,250.</td>
<td>$614.</td>
<td>$17,640 (96%)</td>
</tr>
<tr>
<td>Time</td>
<td>126 days</td>
<td>8 days</td>
<td>118 days (93%)</td>
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</tbody>
</table>
Tool Holders & Covers

MANUFACTURING AIDS

Repair cost = $100s to $1000s

Repair Cost = $100s
Patterns for Molded Parts

CASTING AIDS

- Full size 3D printed pattern
- Urethane part made using silicon mold

Pattern was used in mold box to make silicon mold
Pattern to Cast Compactor Wheel Tip
Pattern to Cast Compactor Wheel Tip

CASTING AIDS
Hose Clamps

Optimization opportunities?
Additive Manufacturing Parts In Process

**Backup Rings**
Printed by: A&I Additive Mfg
Ready for parts orders now

**Dealers-O Ring Installation Tools**
Printed by: A&I Additive Mfg
Ready for parts orders now

**Hose Clamps**
Printed by: A&I Additive Mfg
Ready for parts orders now

**Shade Brackets**
Printed by: A&I Additive Mfg
1st parts sold to fulfill backorder
Southern Germany

**Yokes**
Printed by: PD&GT
Ready for parts orders: TBD
Smart 3D Printing

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✓ Who We Are
✓ Building Engagement & Knowledge
✓ Use Cases