3D printing in machine industry: criteria for success

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Production technology

- Traditional production technology
  - Manufacturing process consists of a number of consecutive processing steps
  - In most cases: subtractive technology → removal (machining) of material (drilling, milling, turning, grinding, etc.)
  - Sequential process steps

- Additive manufacturing (‘3D printing’)
  - Direct CAD/CAM coupling
  - Integrated manufacturing process → parts are built-up
  - Parallel process
Factory of the Future: “Factory 4.0”

Source: Roland Berger Strategy Consultants, March 2014
Fontys ObjeXlab: Research Topics

Additive Manufacturing

Adaptive Robotics
Fontys Objexlab impression
AM Process Technologies
(Selective Laser Melting)
AM Process Technologies
(Fused Deposition Modelling)

The extruder uses torque and a pinch system to feed and retract the filament precise amounts.

The heated filament is forced out the heated nozzle at a smaller diameter.

A heater block melts the filament to a useable temperature.

The extruded material is laid down on the model where it is needed.

The print head and/or bed is moved to the correct X/Y/Z position for placing the material.
AM process technologies
(Stereo Lithography and 3DP)

Stereo Lithography (SLA)

Three dimensional printing (3DP)
(Polyjet (Objet) printing)
Status Additive Manufacturing

• Promising new production technology with high potential
  – Reduction time-to-market
  – Freedom of shape
  – Potential for cost reduction

• Still high degree of unfamiliarity in the industry
  – Hesitation to apply AM technology (‘Unknown, unloved’)
  – AM technology is still in development (‘When should I start?’)

• Still high degree of unfamiliarity in education
  – Especially FDM is used (accessible) → ‘Gadgets’
  – All other AM technologies (especially for metals and ceramic materials) are unknown in most cases
The challenge.....
Market expectations 3D printers

AM market: CAGR 2011-2013: 32.3%

Total machine tool market 2013: $69B (AM:4.3%) Expectation for 2019:$180B (AM: 9%)

Additive Manufacturing: “Killer Applications”

- Application of AM technology to benefit from specific characteristics to achieve competitive advantages that would not be possible with conventional production technologies.

Example: X-ray collimator in Tungsten material (Smit, Best, NL)
AM discriminating characteristics (‘Killer applications’)

• Custom parts
  – Examples: Medical applications, reverse engineering parts (replacement spare parts)
• Freedom of geometry (‘Freeform parts’)
  – Curved holes in parts
  – Lattice patterns (‘honeycomb structures’)
  – Free curved surfaces
• Mass reduction & stiffness optimization
  – Apply material only where strictly necessary
  – Blades and grids
  – Variable material density
• Integration of functions
  – Elastic hinges / manipulation elements / intelligent structures
• Specific material properties
  – Example: Anti reflective (matt) surface for optics
  – Example: Porosity of sintered (SLS) parts for vacuum gripper applications
Example AM ‘Killer applications’: Fountain pen

- Personalized fountain pen
- Material: Titanium (red), Photopolymer (yellow)
- Integrated springs (Ti) in cap of pen
- Price: > € 7,000,-
- AM manufacturing process:
  - Ti parts: SLM
  - Inside of cap: SLA (Stereo Lithography)

Source: SOLide, NL
Example AM ‘Killer applications’: Implants

- Personalized implants
  - Tailor-made: Optimal fit inside the body
  - Better adhesion
  - Better acceptance (less rejection)

Cup for hip implant (source: ARCAM, SE)  
Jaw implant (source: BIOMED, NL)  
Skull implant (source: Materialise, BE)
Example AM ‘Killer applications’: Machine parts

- Integration of functions of multiple parts into one part
- Mass reduction
- Inhomogeneous structures
- Curved holes / channels
- Integral cost reduction

Fuel nozzle (source: GE, USA)  ATB parts (source: Renishaw, UK)  Heat dissipation surfaces (source: Delphi, USA)
Example AM ‘Killer applications’: Integration of parts

- Product: Exhaust gas probe for test engines (exhaust gas temperature up to 2100°C)
- Integration of exhaust gas channels with cooling channels
- Single part design (no additional assembly)
- Cost savings compared to conventional (multiple part) design: 60%

Source: RSC Engineering, DE
Exploring opportunities for Additive manufacturing: Methodology
Questions (first round): Inventarisation

1. Which characteristics are decisive for the difference between your products and your competitor’s products? (= Your competitive edge)

2. How do you realize this difference?
   a. Typical product characteristics that make the difference?
   b. Which parts of your products are decisive?

3. Are there typical AM characteristics (shorter TTM, customizing, freedom of shape, mass reduction, integration of functions) that could reinforce your competitive edge?

4. If yes: Which parts are eligible for this?
Questions (second round): Selection

1. Can you quantify the potential advantages of the selected parts that are eligible for AM (for example: cost savings, reduction of TTM, performance improvement)?

2. Ranking of identified opportunities where an assessment is made of effort (risk) versus potential revenue (reward)?

3. Selection of most promising applications for AM

4. How to proceed (for example: business plan update, AM technology selection, AM supplier selection)?
Redesign for AM, example: GE Bracket (1/2)

- Design contest, issued by General Electric in June 2013
- Price for best solution: $20,000!
- Aim: optimization of bracket design for optimal mass to strength ratio

Original design (mass: 2052 grams)
Redesign (mass: 327 grams)

Alternative 1
Alternative 2
Alternative 3
Alternative 4
"You need almost an artistic approach to design, the ability to model and analyze structures, and also the knowledge to pick the right materials and the correct manufacturing equipment. There is a lot that goes into the mix, and collaboration is the perfect tool for finding the best solution." (Michael Idelchik, Director Advanced Technologies Research at GE)
Example AM ‘Killer applications’: Topology optimization

- Redesign of steel nodes for structural trusses (bridge building)
- Results: stronger joints, better quality, lower costs

Kurilpa suspension bridge, Brisbane, AUS

Source: Arup, NL
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