Industrial 3D Printing – from Rapid Prototyping to Production

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At present, 3D Printing is widely spread in the media...
...creating quite some expectations
Laser sinter parts are produced by layer wise application of powder and exposure by laser.

Additive Manufacturing – functional principle

From a 3D CAD model...

- Application of powder
- Exposure by Laser
- Lowering of platform
- Re-application of powder
- Exposure by Laser

... to complete parts

Works for plastics and metals

Direct – generative – resource efficient

Source: EOS
Laser sintering offers various advantages compared to traditional manufacturing processes.

### Key differentiation criteria for laser sintering

<table>
<thead>
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<th>Cost advantage</th>
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<th>Time to market</th>
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- **Complex components**
  - E.g. alternative structures of heat exchangers

Source: EOS
Sample Lattices
Lightweight is key for aerospace applications

Example lightweight

**Engine cover door hinge**

**Application**
- Engine cover door hinge on the A380
- Material: titanium

**Advantages**
- 65% weight savings compared to conventional casting design (sums up to more than 10kg per aircraft)
- Significant fuel and thus life time cost reduction
- Material efficient process (no wasted material through machine tool stock removal)

Source: EADS, EOS
New design structures in heat exchangers increase compactness and effectiveness

Example complex components

Conceptual heat exchanger

**Application**
- Design study for heat exchanger
- Repeated sub-elements can be formed into almost any shape
- Self-supporting, integrated cooling fins on outside surfaces
- Turbulators inside the cooling tubes disrupt the flow of the cooled fluid
- Material: Aluminum

**Advantages**
- Compact and scalable design
- Maximum heat transfer

Source: Within, 3T, EOS
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Key differentiation criteria for laser sintering

- **Freedom of design**
  - Lightweight
    - Static: weight of parts
    - Dynamic: moving, accelerated parts
  - Complex components
    - E.g. alternative structures of heat exchangers

- **Cost advantage**
  - Integrated functionality
    - Embedded functionality without assembly

- **Customization**
  - Individualized parts
    - Customer specific adaptations
    - Cost efficient small series up to 'lot size one'

- **Time to market**
  - Rapid prototyping
    - Fast feasibility feedback of virtual models
    - Haptic feedback

Source: EOS
Car seats can be designed much lighter and functions can be integrated.

**Example integrated functionality**

- Pneumatic actuator
- Seat ventilation

**Integrated functions**

- Example: Pneumatic actuator
- Example: Seat ventilation

Source: M. Kandler, Fraunhofer IPA, EOS
Festo designed a gripper that is produced in ‘one shot’ and ready to operate

Example integrated functionality

Bionic handling assistant

Application
- Bionic gripper, self adapting to objects
- Movements realized by pneumatically operated membranes

Advantages
- Safe and gentle handling
- Weight 'reduced to the max'
- Highly flexible due to self adapting gripper fingers
- Cost efficient – entire gripper produced in 'one shot', no post assembly

Source: Festo, Fraunhofer IPA, EOS
A conventional handling device was redesigned leveraging the possibilities of laser sintering.

**Conventional design**
- Hole gripper to pick up pieces out of an injection molding machine
- Four grippers mounted on a base plate
- Gripping mechanism operated by distributed compressed air
- Base plate being attached to a three axis robot

**Laser sintered design**

Source: Wittmann, Kuhn-Stoff, EOS
The application perfectly answers today’s Handling & Robotics challenges

Example Handling device: Advantages compared to traditional solution (2/2)

- **Flexibility**
  - Base plate generates light weight stiffness and at the same time allows integrated air channels
  - Three components vs. 21, leading to less list positions and logistics effort

- **Cost per part**
  - **CAPEX reduction**
    - -50% gripper cost reduction
    - -86% less weight leading to smaller robot size
  - **OPEX reduction**
    - Lightweight and smaller build height (-60mm) resulting in shorter cycle times of injection molding machine

- **Time-to-market**
  - Laser Sintered gripper to be produced “overnight”
  - **Reduction** of manufacturing time by 17 days
  - Fast reaction possible for spare parts or product design changes

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Source: Wittmann, Kuhn-Stoff, EOS
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Source: EOS
Customization is believed to be a strong future trend for market differentiation

Example customization

Customization of lamp

Application
- Design lamp
- Customer can adapt the basis design of lamp within given parameters
- Customization 'front-end' available on internet platform

Advantages
- 'Mass customization' – combines individualization and manufacturing possibility
- Absence of molds allows for complex geometries to be created without difficulty
Control on surface roughness

Unique random structure

Complex Design (over 500k struts here)

Pore size fully tuneable
In the medical market, customization delivers high value for patient matched implants

Example customization

Medical implants

Application
- Patient matched implants
- Example hip implants, cranial implants and spine implants

Advantages
- Optimized patient match (e.g. size and strength of an acetabular cup)
- Improved functionality (e.g. enhanced design to stimulate bone growth)
- Reduced cost

Source: Within, 3T, EOS
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**Time to market**

**Rapid prototyping**

- Fast feasibility feedback of virtual models
- Haptic feedback

Source: EOS
The illustration of their ideas has always been a high priority for architects.

Example time to market – architecture model 'ark of the 23rd century'

One picture is worth a thousand words
Chinese proverb

A model is worth a thousand pictures
Obama: “3-D printing that has the potential to revolutionize the way we make almost everything”

President Obama's State of the Union, February 2013

... manufacturers have added about 500,000 jobs over the past three years (Ford, Caterpillar, Intel)

... 3-D printing that has the potential to revolutionize the way we make almost everything

... So tonight, I’m announcing the launch of three more of these manufacturing hubs,

... create a network of fifteen of these hubs and guarantee that the next revolution in manufacturing is Made in America

USA is the frontrunner investing strategically in AM – others will follow

Picture source: The White House
Laser Sintering adds value to industrial applications – and we’re pushing it day by day

Summary

The laser sintering technology is ready for operation – large OEMs start using it as production technology

Customization and freedom of design as well as cost and productivity advantages are key differentiators

Gripper applications perfectly profit from Laser Sintering advantages

We develop our portfolio to consistently add value to our customers

Source: EOS
Thank you for your attention!

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