Design approaches for additive manufactured components

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AM at VTT: from raw materials to final component design

Experimental: materials, process, post-treatments

Powder & alloy design

Process simulation

Component optimization & design

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Selective laser melting (SLM)

Sliced 3D CAD Model

Distribute new powder layer

Metal Powder

Image from http://www.lpwtechnology.com/

SLM 125
- Powder bed fusion technology
- Maximum build size: 125x125x125 mm
- Materials: stainless steels, tool steels, Inconel, cobalt-chromium, aluminum, titanium, etc.

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Metal AM overview

- Geometric freedom
  - Functional design, e.g. complex internal structure
  - Lightweight design – hollow or lattice-filled structures
- Customizable with no additional tooling or manufacturing cost
- On-demand manufacturing
- Reduction in material waste

- Cost – manufacturing, post-processing (support removal, machining, heat treatment, etc.)
- Quality assurance - repeatability/predictability of final product

Customized redesign of low volume, high value-added components

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General AM design approach

- Systematic concept design
- Benefit more from AM
  - Minimize use of material
  - New functionality
- Minimize post-processing
- Simulation based design
- Optimize: topology, shape, size

Take advantage of geometric freedom
- Lattice structures
- Internal channels
- Internal cavities
- Part consolidation

- Optimize print orientation
- Self-supporting shapes

Properties of a successful AM product
- New functionality
- Lightweight, compact
- Short build time
- Single consolidated part
- No assembly needed
- Minimal machining & finishing

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Minimize material usage

- Reduce costs $\rightarrow$ less material, lower print time, minimal post-processing

- Three common design approaches:
  - Topology optimization
  - Lattice structures
  - Self-supporting structures
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Workflow – topology optimization in design for AM
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  - Self-supporting structures

Example – topology optimization of a welding head bracket
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Integrate lattice structures into design \(\rightarrow\) self-supporting & excellent strength-to-weight ratios

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Example – lattice optimization of welding head bracket

In cooperation with: meconet
Improve performance & functionality

- Internal channels and cavities
  - Improve fluid flow
  - Heat transfer
  - Integrated electronics/sensors
- Parts consolidation
Improve performance & functionality

- Internal channels and cavities
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  - Heat transfer
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Example – hydraulic valve block with improved fluid flow and decreased chance of leakage
Improve performance & functionality

- Internal channels and cavities
  - Improve fluid flow
  - Heat transfer
  - Integrated electronics/sensors
- Parts consolidation

Example – conformal cooling in tool used for plastic injection molding (Texer Design)

www.texerdesign.it/en/tecnologia/conformal-cooling/
Improve performance & functionality

- Internal channels and cavities
  - Improve fluid flow
  - Heat transfer
  - Integrated electronics/sensors
- Parts consolidation

Examples – parts consolidation in engine and fuel nozzle (GE Additive)

www.geadditive.com/
Conclusion

- Metal AM won’t replace traditional ("subtractive") manufacturing techniques, but it opens the door for new possibilities in cases where added value can be derived from clever use of increased geometric freedom in design.

- An understanding of the manufacturing process – including design limitations, print planning (position, orientation, support structures), and post-processing (heat treatment, support removal, machining) is crucial for successful component design.

- Rapid improvements in print time, process control, materials, cost, and the increased ability to simulate and predict geometric accuracy, defects and stress state will continue to add to the number of cases where metal AM becomes the preferable manufacturing option.
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