How Software helps drive the industrialization of Additive Manufacturing

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Siemens Power Generation
Gas turbine is a focal area for the use of Additive Manufacturing

Combustion System
- Burner
- Swirler/Nozzle/Filter/Mixer

Turbine
- Blades & Vanes

High Tech Components with complex design and high potential to improve customer value (efficiency, durability)
The first full load test of 3D printed gas turbine blades

https://www.youtube.com/watch?v=8vtLtu4ZYsQ
Challenges: Industrializing Additive Manufacturing

- Conventional thinking
- Multiple data conversions
- Uncontrolled workflow
- Disconnected software
- Certification
Siemens PLM Vision:
One integrated end-to-end system for industrializing Additive Manufacturing

Smart model-driven process

Design
Simulate
3D Print

Data Management and Shop Floor Connectivity
Siemens Production Software and MES Systems
Partnerships

NX and Simcenter
Teamcenter
Simatic IT

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Design for Additive Manufacturing

Convergent Modeling™ Technology

Work directly on a mix of faceted and exact solid Brep geometry within a single model

Unlimited flexibility to design innovative products

No need for reverse engineering
https://www.youtube.com/watch?v=WaZZpey7tJ0
Topography Optimization

All operations in NX CAD

Multiple load cases

Optimized model can be refined with Convergent Modeling
Design for Additive Manufacturing

Lattices*

Lightweight components and structural integrity

Integrated lattice structure development

* Available soon
Design Rules

Ensure the manufacturability by checking:
- Wall Thickness
- Overhang Angles requiring supports
- Enclosed voids

Avoid costly re-design when a part is designed and found to be inadequate during manufacturing.
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Simulate for Additive Manufacturing

PREDICT PERFORMANCE

• Optimize part design with advanced analysis tools
• Validate product performance
• Simulate additive processes
Simulate for Additive Manufacturing: Validation for impact of additive process
Example: Simulate powder bed processes – micro scale

Particle Flow / Filling (Discrete Element Modeling – DEM)
Powder manufacture and powder bed distribution

Melting / Solidification (Volume of Fluid – VOF)
Powder melting simulation (e.g. EBM)

Energy transfer
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Partnerships
Partnering with leading Additive Manufacturing OEMs

**Metal deposition**
- Released
- DMG MORI

**Metal powder bed**
- Released

**Plastic fused deposition modeling (FDM)**
- Scheduled for 2017

**Plastic 3D printing**
- Scheduled for early 2017
- Soon to be announced
Siemens and DMG MORI - Hybrid Manufacturing Solution
Multi-axis deposition combined with NC Machining

**Solution components:**
- LASERTEC machine tool (DMG MORI)
- NX CAM Hybrid Additive software (Siemens)
  - Additive Multi-axis deposition manufacturing package
  - Advanced 2-5 Axis Milling package
  - Postprocessor and Simulation

**Available for 3 machine configurations:**
- LASERTEC 65 3D
- LASERTEC 65 3D FD version
- LASERTEC 4300 3D

All machines are equipped with Sinumerik 840D SL
DMG MORI
Aerospace Casing - Demo

https://www.youtube.com/watch?v=L3CkzQQFZXs
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Powder bed fusion – typical workflow

A model-driven process in NX

Design model

Select a 3D printer → Position / nest parts on build tray → Create support structures → Define the build strategies → Verify the laser path → Drive 3D printers → Printed part
Post-processing

Integrated NX CAM

 Produce high quality parts with precise toolpaths

 Automate NC programming

 Program any part using a wide range of capabilities

 All in one system
Additive manufacturing of plastic parts with NX

Drive the latest HP jet fusion 3D printers
Partnering with leading Additive Manufacturing OEMs

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Multi-Axis Fused Deposition Modeling

Build composite parts in various sizes

Leverage robots flexibility to print parts of any complexity

Eliminate support structures
Multi-Axis Fused Deposition Modeling
Robotic composite 3D demonstrator

Integration of Stratasys’ advanced extrusion technology, Siemens MC industrial motion platform and Siemens PLM design-to-product workflow

https://www.youtube.com/watch?v=u_pSEhF3q3Q
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Data Management and Shop Floor Connectivity

**Single source of data**
- Manage all the manufacturing data
- Manage access; revisions; workflows
- Re-use proven data and processes

**Connect engineering to the shop floor**
- Deliver the correct data to production
- Establish a closed-loop process
Manufacturing Operations Management
Embed Additive Manufacturing activities in the overall production process

Manage all pre / post 3D printing operations

Order management
Additive Manufacturing management
Operator guidance and checklist
Print job file management
Powder and substrate management
Full production data tracking

* Available soon
Work Order information for burner tip repair is retrieved from SAP and a Work Order (typically for 30 burners) is generated in MES.

- The list of Serial Numbers is associated with the Work Order
- The Work Order is based on a fixed production process consisting of 14 steps including all operations: preparation, AM and post-processing
- The production coordinator dispatches Work Orders according to priority and work load.

Contextualize AM within the whole production process.
Shop-Floor Operators are guided step-by-step in their daily activity, in terms of:

- What operation to execute, according to priority and constraints.
- Instructions about how to perform the task at hand: documents, pictures, resources, etc.
- What data to insert/upload for traceability purposes.

Select the correct revision of the Print Job File from Teamcenter and transfer it to the EOS machine
Siemens PG Finspång – Burner Tip Repair use case
Activity Report / Traceability

Upon completion of activity on all Serial Numbers, the Work Order switches automatically to **COMPLETED** status and is taken out of the queue for shop-floor operators.

An activity report is available by Work Order Identifier and by Serial Number.

**Detailed reporting.**
Conclusions

- Additive Manufacturing is introducing revolutionary new manufacturing capabilities.

- The industrialization of Additive Manufacturing requires software that addresses the specific AM requirements for Product Design, Product Performance Simulation, Manufacturing as well as Data & Manufacturing Operations Management.

- Support for these specific Additive Manufacturing requirements has to be an integral part of the PLM technology suites that are already established in the industry.

- The PLM vendors, including Siemens PLM, were not the first to join, but they understand the requirements that have to be met to take Additive Manufacturing out of the laboratory.

- Convergent Modeling technology and manufacturing planning that is associative to the design will enable concurrent engineering and minimize rework.

- We @ Siemens “eat our own dog food”
Thank you

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