Design for Additive Manufacturing

What’s limiting your potential?

- Performance
- Design complexity
- Weight
- Material properties
- Speed to innovation

- Lead time
- Inventory
- Cannot make the shape
- Serviceability
- Carbon footprint

Design

Manufacturing

Design for Additive Manufacturing
Impact of additive design to production processes

• End-to-end support to design, optimize and produce parts using additive manufacturing processes is revolutionizing the way future structures are developed
• Siemens is leading in the development of next generation software and processes to enable this shift
Additive unlocks the next frontier of possibility

Transform thinking from ‘Conventional’ to ‘Additive’

REIMAGINE PRODUCTS
- Reduce weight, material
- Personalize, customize
- Expand performance

RETOOL MANUFACTURING
- Add complexity for no cost
- Reduce steps, setups, tooling

RETHINK BUSINESS
- Accelerate innovation
- Digital (not physical) inventory
Design for Additive Manufacturing

REIMAGINE PRODUCTS

- Design with Convergent Modeling™
- Generative design using topology optimization
- Lattice structures
- Design rules for manufacturability
Design for Additive Manufacturing
Traditional and new design workflows supported

From Traditional Prototyping

TO...

Scan to print

Optimize to print

Design | Prepare | Make

Scan | Simulate | Modify | Make

Design | Optimize | Validate | Make
Convergent Modeling™ Technology

Work directly with facets surfaces and solids

Unlimited flexibility to design innovative products

No need for reverse engineering
Convergent Modeling™ technology

Design without conversion

10x faster than traditional methods!
Topology Optimization

All operations in NX CAD

Multiple load cases

Optimized model can be refined with Convergent Modeling
Lattices

Lightweight components and structural integrity

Integrated lattice structure development

Complex geometry represented as facets
Design for Additive Manufacturing Topics

- Current Situation
- Siemens Solution
- Common Workflows
- NX Design for Additive Manufacturing (CAD)
- Case Study
- Roadmap
The Current Additive Manufacturing Workflow

Design Software
- Vendor A
- Vendor B
- Vendor C
- Vendor D
- Vendor E

MFG Software
- Vendor V
- Vendor W
- Vendor X
- Vendor Y
- Vendor Z

Hardware
- Vendor V
- Vendor W
- Vendor X
- Vendor Y
- Vendor Z
The Siemens Additive Manufacturing Workflow

Siemens NX

- Design using NX CAD
- Analysis using Simcenter

Preparation using NX CAM

Hardware

- Vendor V
- Vendor W
- Vendor X
- Vendor Y
- Vendor Z
Common Workflows

Topology Optimized Parts
- Analyze
- Optimize
- Redesign
- Refine

Lightweight Structures
- Export
- Lattice
- Import
- Trim / Unite
Common Workflows

Scanned Geometry (repair, etc.)

Scan → Analyze → Create/Modify → Print
Common Workflows – Single Environment

Topology Optimized Parts

Analyse  Optimize  Redesign  Refine

Lightweight Structures

Export  Lattice  Import  Trim / Unite
Convergent Modeling

Capability in NX 11

• NX design can *work with facets as any other geometry*!
• Direct use of scan and polygon/facet data without conversion
  • No need for reverse engineering!
• History based modeling with facet geometry
  • Boolean/Trims
  • Associative wireframe
  • …

Business value

• Accelerate concept to production workflows through increased use of polygon/facet data
### Additive Design Rules & Checking (NX 11.0.1)

#### License
- nx_additive_design

#### Wall thickness
- Set threshold for minimum thickness

#### Overhang angle
- Recognize part regions that require support

#### Printable volume
- Ensure that part fits within the 3D printer build volume

#### Wholly enclosed volume
- Identify fully enclosed voids within a part
Lightweight structures design
Update NX 11.0.2 accelerated investments

Fill a solid volume with lattices for part light weighting and material reduction while supporting the required loads

License
• nx_additive_lattice…
Demonstrations

Optimise

Prepare

Light Weighted

Analysed
Case Study – Industrial Burner Tip Redesign
Functional-driven redesign of burner tip

Conventional Burner Design

Disadvantages:
- Nested, ring-shaped fluid channels
- Complex assembly (total length 2 meters)
- Large length of supply system
- Many parts, flanges, welds
- High manufacturing cost / lead time

Total length $L = 3.4 \text{ m}$
Functional-driven redesign of burner tip

Conventional Burner Design

Burner tip

Basic Idea:
Use pipe connections for Burner tip to reduce complexity of assembly

Tools:
Siemens NX for CAD-Design
CD-adapco STAR-CCM+ for CFD simulation.
HEEDS for parametric fluid optimization

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- HEEDS/Optimate for parametric fluid optimization

Redesign for Burner tip using AM design freedom

Redesign with redesigned tip

New Burner Assembly with redesigned tip

Total length $L = 1.7 \text{ m}$

Targeted use of AM to improve system

Complexity
Functional-driven redesign of burner tip

<table>
<thead>
<tr>
<th>Indicators of Assembly Effort</th>
<th>Burner Assembly with Conventional Tip</th>
<th>Burner Assembly with Redesigned Tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Parts</td>
<td>45-50</td>
<td>19</td>
</tr>
<tr>
<td>Number of AM Parts</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Number of Welding Seams</td>
<td>&gt;43</td>
<td>24</td>
</tr>
<tr>
<td>Length of Front Section</td>
<td>1.4m</td>
<td>1.4m</td>
</tr>
<tr>
<td>Length of Rear Section</td>
<td>2.0m</td>
<td>0.3m</td>
</tr>
<tr>
<td>Overall Length of Burner</td>
<td>3.4m</td>
<td>1.7m</td>
</tr>
</tbody>
</table>
Burner Tip Cooling Water Flow Analysis
HEEDS – Multi-Objective Design Exploration

Optimize with parameter driven CAD or mesh morphing.

Rapid attainment of optimal designs considering competing objectives.

Multidisciplinary optimization

High level of automation.

Large ecosystem of integrated solvers

In PLM context, configurations are stored and managed and can be reused.
Oxygen and Water Optimized Fluid Dynamics
Burner Tip Model
**NX Roadmap**

- Convergent Modeling Improvements
- Lattice structure modeling
  - Unit Cell (NX 11.0.2)
  - Conformal (NX 12)
  - Transitions
- Geometry preparation tools (fixing/manipulation)
- Markings/labels (special + internal)
- 3MF export
- Build orientation optimization
- Multi-color bitmap wrapping
- Parasolid high-performance lattice representation
- AM Electro-mechanical design
- Surface Texture modeling
- Graded color/material modeling

![Lightweight Structures](image1.png)

![Graded Materials](image2.png)
Thank You!