Opportunities and Challenges with Additive and Subtractive Manufacturing

Allessandra McGinnis
Senior Product Manager for Additive, Cutting, & Composites Manufacturing
About Me

Senior Product Manager
Additive, Cutting & Composites
Manufacturing Software

Previously at:

Shapeways
Microsoft

© 2017 Autodesk
Agenda

Global Product Data Interoperability Summit | 2017

Why Additive + Subtractive

Opportunities with Better Planning & Data Management

Challenges

Future Automation Implications

Image courtesy of Under Armour
Why Additive Manufacturing?

Prototyping & visual aids

Impossible geometries

Custom medical implants

Part consolidation
Types of Additive Manufacturing

Metal

- DED
- DMLS
- SLM

Polymers

- DLP
- Material Jetting
- FDM

Image courtesy of Stanley Black & Decker

Image courtesy of Under Armour
Additive Manufacturing Workflow

Global Product Data Interoperability Summit | 2017

- Lattices, Topological Optimization, Generative Design
- Design Part in CAD Tool
- Design for Additive
- Plan for Manufacturing Process
- Plan for Post Processing
- Simulate Printing Process
- Identify Expected Part Warpage During Print Process
- Print Preparation
- Print Part
- Drive 3D Printing Machine
- Post Processing

**Supports** (in purple) that hold the part up and try to prevent deformation while printing that have to be removed after the print is done.

**Part** (in grey)

Add additional material to part going into the printer that will be machined off later for surface finish so you have accurate dimensions in your final part.
# Challenges with Additive Manufacturing

## Global Product Data Interoperability Summit | 2017

<table>
<thead>
<tr>
<th>PART DISTORTION AND PRINT FAILURES</th>
<th>CREATING COMPLEX, ORGANIC FORMS</th>
<th>MACHINE UTILIZATION &amp; THROUGHPUT</th>
<th>PLANNING CNC FINISHING OPERATIONS</th>
</tr>
</thead>
</table>

Simulation Results

![Simulation Results](image1)

![Simulation Results](image2)

![Simulation Results](image3)

?
Why CNC? Why Post Processing?

Labor: e.g. Remove Supports From Part and Print Bed – By Hand or Machine

Design Goals: Building to Tolerance, Design Goals
Why CNC? Why Post Processing?

Accuracy of Critical Surfaces

• Smaller tolerances than AM machine capabilities

Goal: End Product Looks Like This

3D Model at End of Design Process

Requirements

- Drill Holes in Top & Smooth Surface Finish
- Smooth Surface Finish + Precise Tolerances

Goal: End Product Looks Like This

3D Model at End of Design Process
**Goal:** End Product Looks Like This

3D Model at End of Design Process

**Draft Manufacturing Plan**

- #1 print
- #2 drill
- #3 heat
- #4 wire
- #5 ream
- #6 mill

Add material where subtractive operations will occur.
Orient and fixture for print.
Challenge: Planning for the Manufacturing Process

Manufacturing Plan

#4 wire
#5 ream
#6 mill
#2 drill
#1 print
#3 heat
Challenge: Planning for the Manufacturing Process

Manufacturing Plan:
- #4 wire
- #5 ream
- #6 mill
- #2 drill
- #1 print
- #3 heat

Print
Challenge: Planning for the Manufacturing Process

Manufacturing Plan

#4 wire
#5 ream
#6 mill
#2 drill
#1 print
#3 heat

Print
Drill

Drill can't access holes

Design a new manufacturing plan
Challenge: Planning for the Manufacturing Process

Global Product Data Interoperability Summit | 2017

New Plan

Manufacturing Plan

#3 wire
#4 ream
#5 mill
#1 print
#2 heat
#6 drill

Print
Challenge: Planning for the Manufacturing Process

Global Product Data Interoperability Summit | 2017

New Plan: Manufacturing Plan

- #3 wire
- #4 ream
- #5 mill
- #6 drill
- #1 print
- #2 heat

Print

Heat
Challenge: Planning for the Manufacturing Process

Global Product Data Interoperability Summit | 2017

New Plan

Manufacturing Plan

#3 wire
#4 ream
#5 mill
#6 drill
#1 print
#2 heat

Print
Heat
Wire EDM
Challenge: Planning for the Manufacturing Process

Print  Heat  Wire EDM  Ream

#3 wire  #6 drill  
#4 ream  #1 print  
#5 mill  #2 heat  

New Plan

Manufacturing Plan
Challenge: Planning for the Manufacturing Process

Global Product Data Interoperability Summit | 2017

Manufacturing Plan

#3 wire
#4 ream
#5 mill
#6 drill
#1 print
#2 heat

New Plan

Print
Heat
Wire EDM
Ream
Mill
Challenge: Planning for the Manufacturing Process

Global Product Data Interoperability Summit | 2017

New Plan

Manufacturing Plan

#3 wire
#4 ream
#5 mill

#6 drill
#1 print
#2 heat

Print Heat Wire EDM Ream Mill Drill
Challenge: Planning for the Manufacturing Process

Global Product Data Interoperability Summit | 2017

Print  Heat  Wire EDM  Ream  Mill  Drill

CAD Model #1
Challenge: Data & Model Management

Global Product Data Interoperability Summit | 2017

Print  Heat  Wire EDM  Ream  Mill  Drill

CAD Model #2  CAD Model #3  CAD Model #4  CAD Model #5  CAD Model #1

Job Sheet 1  Job Sheet 2  Job Sheet 3  Job Sheet 4  Job Sheet 5  Job Sheet 6
How To Tackle These Challenges: Plan AM + SM Together

Mark-up – capture minimum requirements for manufacture directly on the CAD parametrically

Add stock to your model that will be machined away

Keep Stock Model Data Delineated from Core CAD Model
How To Tackle These Challenges: Plan AM + SM Together
Orient, Support, & Simulate on the Model You Will Print

Global Product Data Interoperability Summit | 2017

Orient

Support

Simulate Process

Part name: AMC-020-200
Z-height: 46.36 mm
Build height: 50.93 mm
Projected area: 7247 mm²

Poor accessibility: 0 mm²
1 mm²
2.752 mm²
514 mm²
514 mm²
Total fixture area: 3267 mm²
Run Process Simulation on the Model You Will Print

DISTORTION

RECOATER INTERFERENCE

LACK OF FUSION

SUPPORT FAILURE

STRESS & DISTORTION

LACK OF FUSION
Specify the Reference Datums for Post Processing
Keep Your Data Connected – Export to AM and SM at Same Time

Global Product Data Interoperability Summit | 2017
Manage Your Data Across Your Factory Operations

Global Product Data Interoperability Summit | 2017

AGILE PRODUCTION NETWORK

COMMON DATA ENVIRONMENT

DISTRIBUTED MANUFACTURING

PRODUCT DESIGN

CAD

DESIGNER

MACHINE OPERATOR

PRODUCTION SUPERVISOR

MFG. ENGINEERING

CAM

JOB SHEETS

COMPLETION DETAILS

REPORTING

MACHINE DATA

COMPONENT SUPPLIER

MACHINE OPERATOR

PRODUCTION SUPERVISOR

MFG. ENGINEER

WORK INSTRUCTIONS

PRODUCTION FACTORY

MACHINE DATA

REPORTING

COMPLETION DETAILS

JOB SHEETS

COMMON DATA ENVIRONMENT

MANUFACTURING

COMMON DATA ENVIRONMENT

MANUFACTURING
Summary

Global Product Data Interoperability Summit | 2017

Plan Your Process

- Print
- Heat
- Wire EDM
- Ream
- Mill
- Drill

Minimize Data Loss

Prep for the Right Model
For Each Phase of Manufacturing
Automation: Additive, Post Processing, Assembly

Image courtesy of Under Armour
Thank you.
Questions?

allessandra.mcginnis@autodesk.com