#### Manufacturing Industry Futures

By Nick Markovic Senior Technical Consultant, Autodesk Research

#### AUTODESK.

#### MANUFACTURING INDUSTRY FUTURES Who we are

AUTODESK.

### Our team

1.





#### **OUR VISION**

Realize the future of manufacturing with our customers and partners so we can make more and better products, all with less negative impact on our world.



#### **OUR MISSION**

Make our customers successful by exploring and providing innovative technology solutions that enable them to make new things in ways they never could before.





### Our innovative applications





#### **MANUFACTURING INDUSTRY FUTURES** Converging design and manufacturing

AUTODESK.

### AUTODESK GENERATIVE DESIGN



N



MA

W



A

W





































M













































M



M































































































# HOW IS AUTODESK GENERATIVE DESIGN DIFFERENT?





# Convergence of design & manufacture workflow



### Prove that we can make it



0







### Autodesk technology centers











#### **MANUFACTURING INDUSTRY FUTURES** Technology focused areas

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### Hybrid manufacturing





# Hybrid manufacturing in aerospace



#### CHALLENGE:

- Can we break the barrier using AM techniques on structural critical components?
- How do we exploit new manufacturing technologies for further weight savings? **OUR SOLUTION:**
- Additive manufacturing plus generative design opens up a whole new design paradigm
- Use lattice optimization and 3D-printing to dramatically light-weight the seat frame
- The seat frame is made out of Mg alloy. **BENEFITS:**
- Significant fuel savings and reduction in CO2 emissions over lifetime of part

Generative Design & Optimization + Additive manufacturing + Metal casting manufacturing

# Extracting pattern & securing onto tree

# Slurry dipping



#### **Burn-out**



# Metal pouring

# De-shelling



### Adaptive manufacturing



8000

INO

# Fancy hand polishing?







Robot polishing,



# **Robotics manufacturing**







#### **TECHNOLOGY SOLUTIONS** DfAM in injection molding

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# Why 3D print metal mold tools?

#### **Benefits of AM**

- Allows very high resolution and precision (layer thickness 20-100mm)
- Allows the user to produce very complicated parts (Generative Design or latticed optimized structures)
- More design freedom with increased performance
- Unused feedstock can be recycled and minimise waste (e.g. buy-to-fly ratio is low)
- Competitive costing for low production
- Part consolidation (e.g. GE fuel nozzle from 20 parts into one)





AM fuel nozzle Source: www.ge.com

### The next steps?

**Fatigue characteristics of AM metals** 



Surface roughness effects





EBSD mapping of SLM S316L Source: Riemer A et al, Eng Fract Mech 2014;120:15–25

Post processing exploration

### The next steps?

#### **Fatigue testing**

- We are looking to conduct testing according to:
  - ASTM E466 The relationship between stress and number of cycles
  - ASTM E647 The relationship between Fatigue crack growth rate and stress intensity factors
- We are currently working on publishing material data soon for:
  - Ti-6Al-4V
  - Inconel 718
  - AlSi10Mg
  - Maraging steel

#### Data used for safe life design



#### Data used for Damage tolerance design



### What is the Future of AM?

#### Larger powder beds



Aerosud Aeroswift - Build plate 2000x600x600 (mm)

#### Reducing labour & improve process quality

![](_page_35_Picture_5.jpeg)

Additive Industries – Ranging from 3 to 11 modules)

#### **Reduced costs**

![](_page_35_Picture_8.jpeg)

Xact Metal XM200C L-PBF machine – Build plate 127x127x127 (mm)

#### Hybrid machining

![](_page_35_Picture_11.jpeg)

Matsuura - Matsuura LUMEX Avance-25

### What is the Future of AM?

#### Improved capability

![](_page_36_Picture_2.jpeg)

3D Microprint – Layer thickness 1-5 µm

#### High temperature L-PBF

Build chamber reaches up to 1000 degrees Celsius!

![](_page_36_Picture_6.jpeg)

Evobeam SLaVAM

#### Laser wavelength

![](_page_36_Picture_9.jpeg)

*Trumpf – L-BPF print copper parts* Higher production rate

- Larger machines
- Multiple laser machines
- Robotic post processing

![](_page_36_Picture_14.jpeg)

AM fuel nozzle Source: www.ge.com

### **Better performance**

#### How can this be related to mold tooling?

![](_page_37_Figure_2.jpeg)

Improved part quality

• Production – the existing tool can be modified

Maintenance – able to repair damaged tool

Surface

As-built

finished

As-built

Machined

Polished

As-built

Turned

As-built

As-built

Polished

Machined

-1 vibratory

-1 Turned

condition

Ra (µm) Reference

[74]

[74]

[74]

[30]

[30]

[30]

[60]

[60]

[32]

[32]

[35]

[35]

13.29

1.74

1.08

10.0

0.4

0.1

0.2

13.7

2.587

0.198

\_

Smooth cooling channels

Minimise surface defects

R

-1

0.1

0.1

0.1

-1

-1

0

0

-1

-1

Increase tool life

•

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•

![](_page_38_Picture_0.jpeg)

DRE.

SPEEDGRI

LESS

SDE

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