AM Process Simulation

(30 minutes)

Co-funded by the
Erasmus+ Programme
of the European Union

Session Objectives

- To understand the benefits of using AM process simulation
- Identify key types of simulations used for polymer AM processes
- Example PBF-LB and MEX simulation setup

Co-funded by the
Erasmus+ Programme
of the European Union

Common challenges in AM processes

New defects with AM

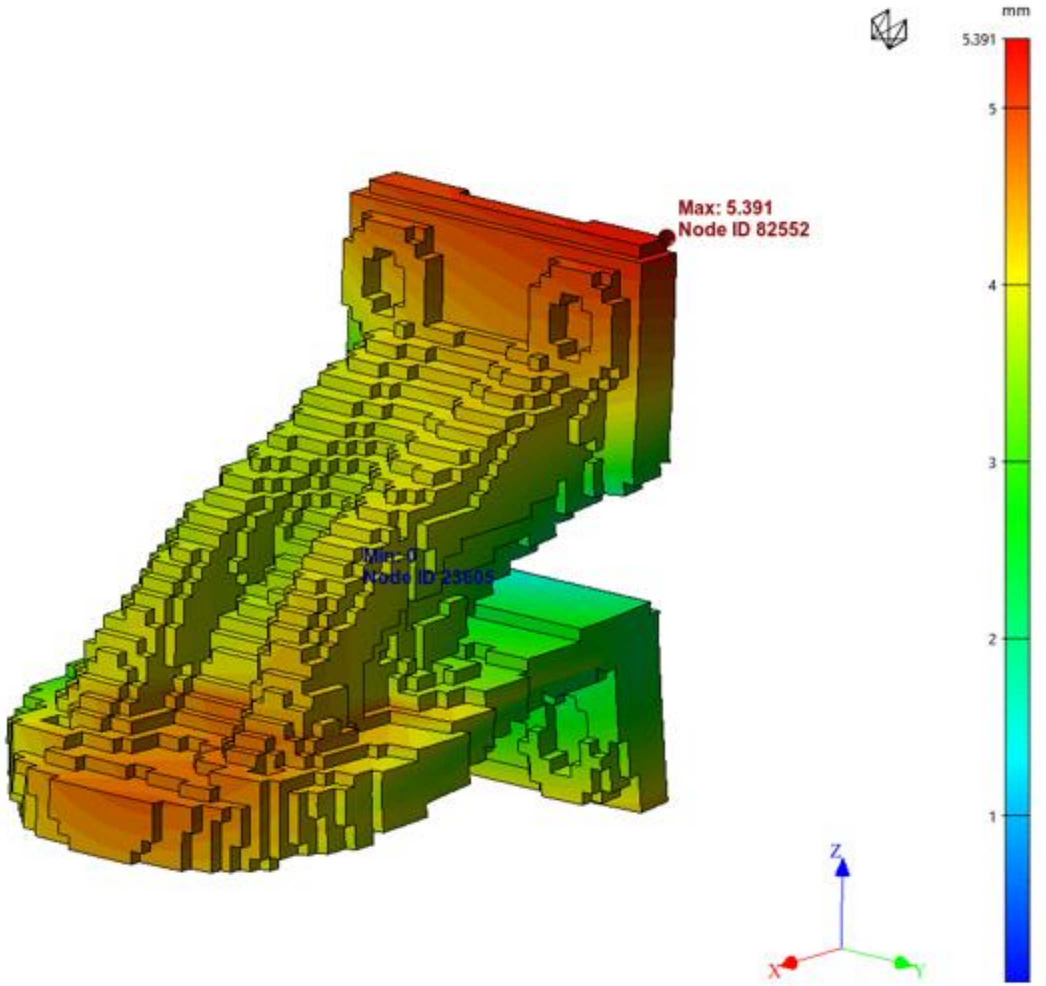
- Porosity/voids between tracks in PBF and MEX
- Thermal distortion due to processes involving heat (PBF, MEX)

Generally, commercial simulation software offer PBF and MEX simulation only.

Co-funded by the
Erasmus+ Programme
of the European Union

Benefits

- Simulation can help reduce variability and risk in PBF and MEX processes.
- It also permits prediction and visualisation of in-process effects that would be impossible to see during physical trials
- Effective use of simulation provides a greater understanding of the AM process and means more informed design decisions can be taken



© MTC/CALM, all rights reserved.

Key types of polymer AM simulation

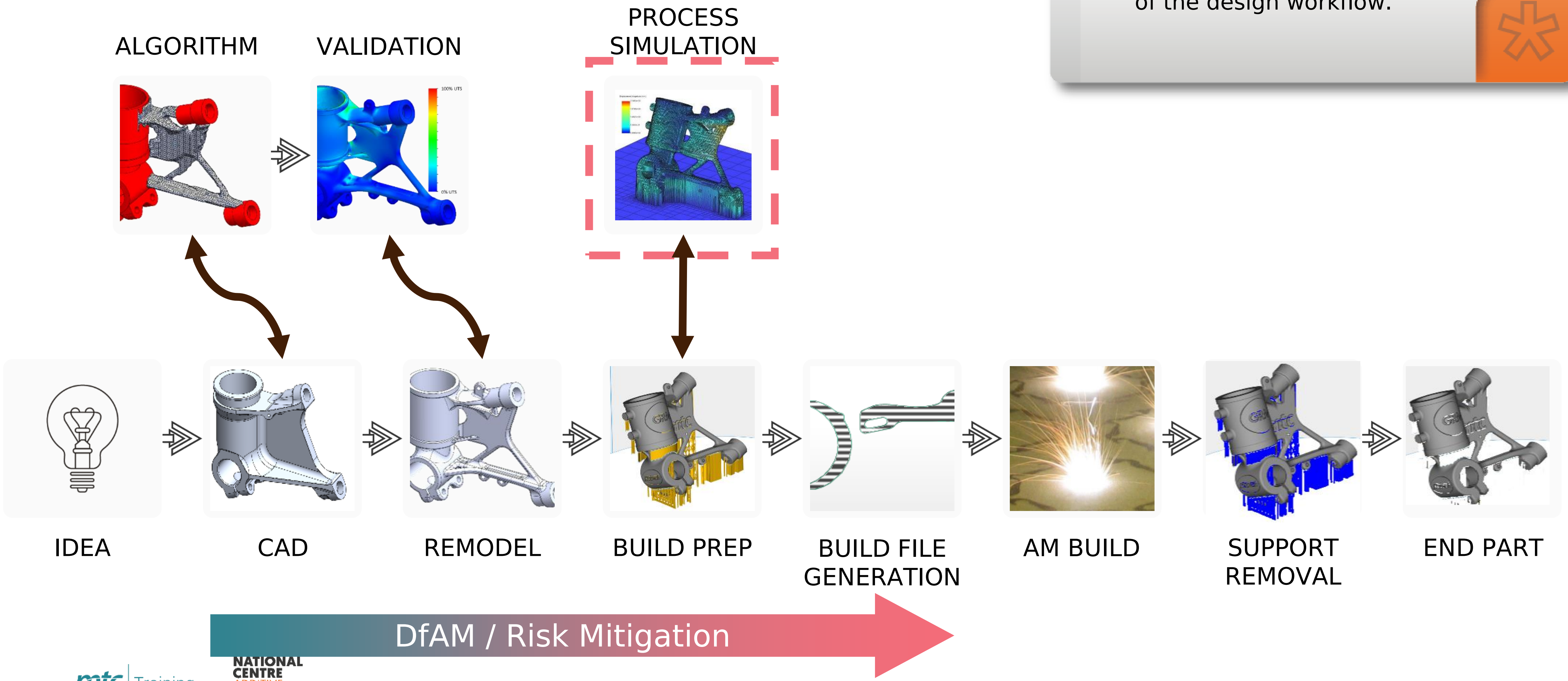
- Thermomechanical simulation
  - Calculates the structural and thermal behaviour of parts shrinking and deforming during AM process
    - Thermo-Visco Elastic (TVE) model (recommended due to its relative accuracy for pre-distortion)
    - Thermo-elastic (TE) models (excludes relaxation or viscous behaviour of polymer)
- Inherent strain (IS) method
  - IS employs strains that are inherited from the thermomechanical process and allows for calculation of the deformed shape
  - Reduces the complex thermomechanical problem into a simple mechanical one
  - Faster and relatively less accurate

Co-funded by the
Erasmus+ Programme
of the European Union

CAD to Machine

Key Takeaways

- Simulation should be part of the design workflow.

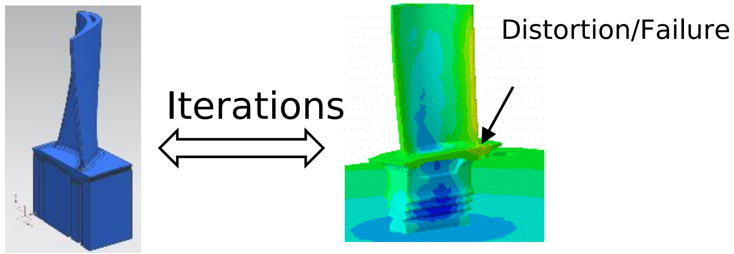


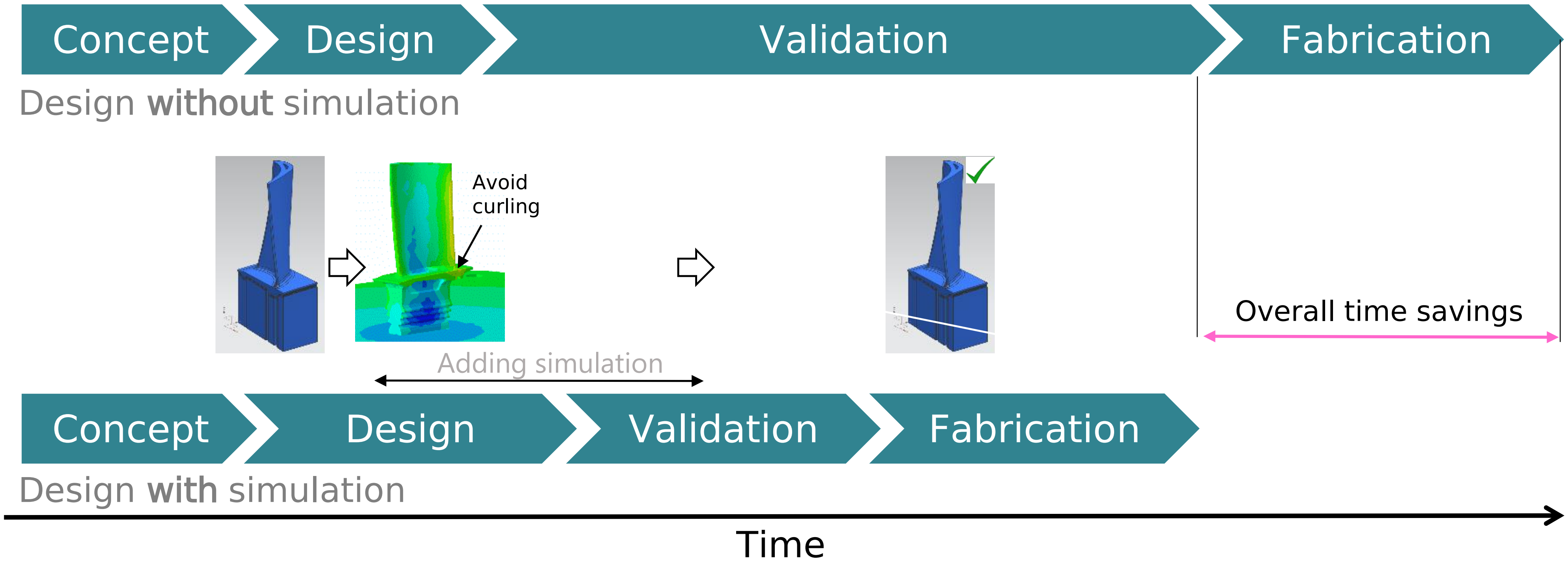
mtc Training

NATIONAL CENTRE ADDITIVE MANUFACTURING

Source:

Benefits of simulating pow fusion





Key Takeaways

- Simulation can reduce lead time for a component.
- It can also reduce cost by enabling “right 1st time” builds.

mtc Training
NATIONAL CENTRE ADDITIVE MANUFACTURING

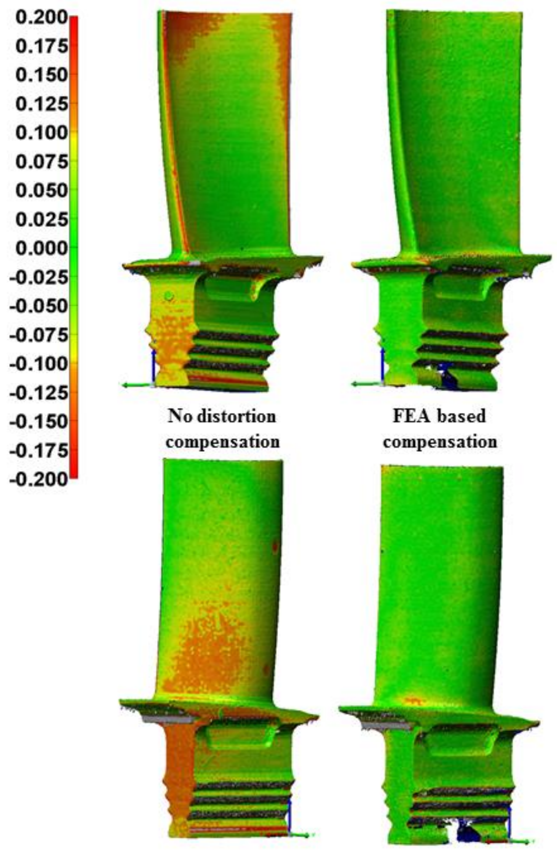
Source:

Current uses for simulatio

Key Takeaways

- Simulation can predict the distortion of the parts and the forces on the supports.

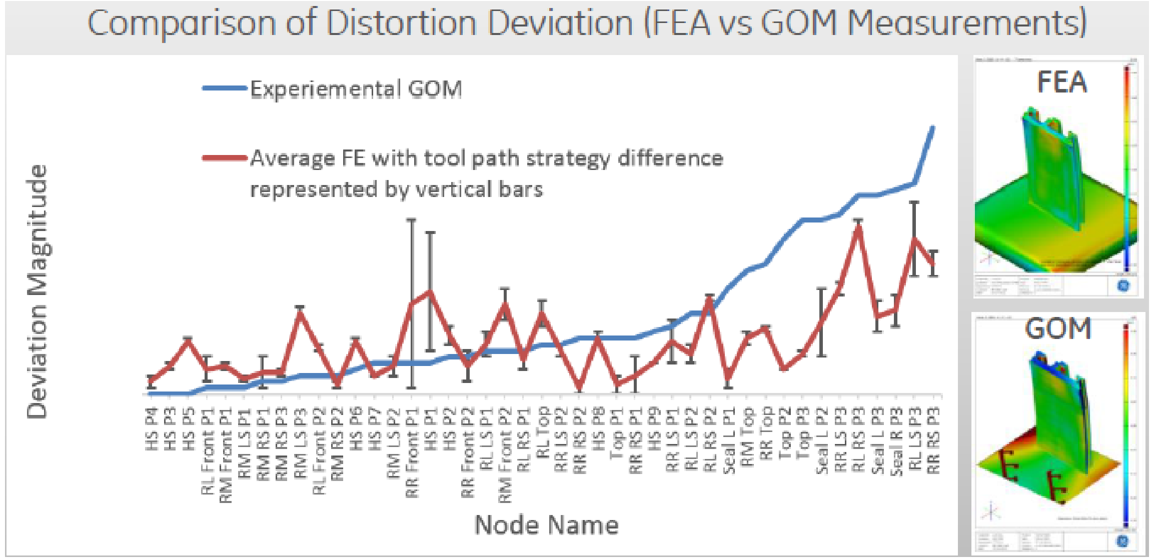
Distortion prediction and compensation

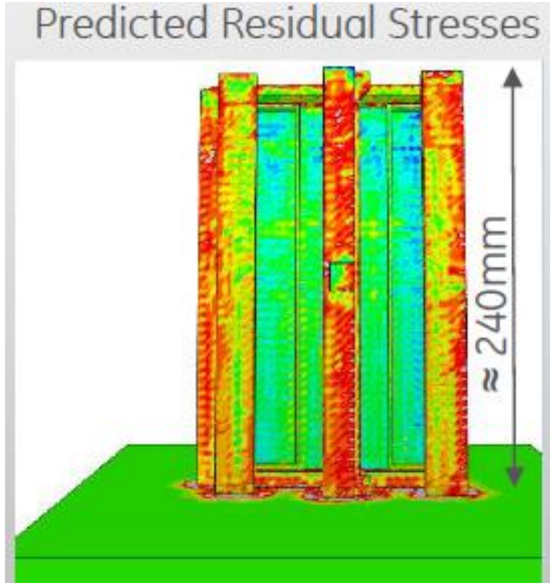


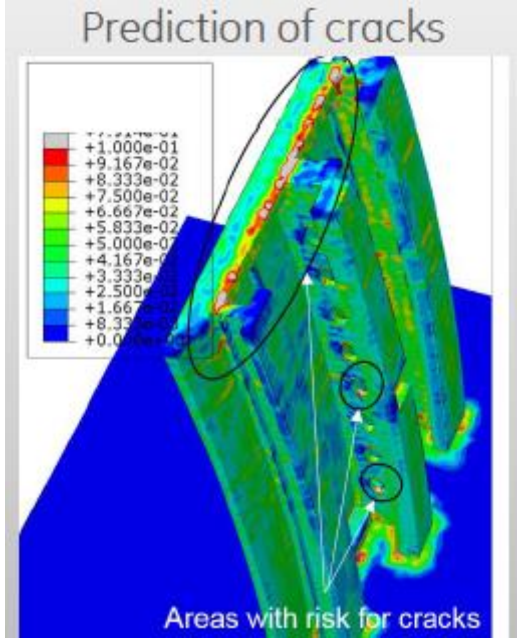
mtc Training
NATIONAL CENTRE ADDITIVE MANUFACTURING

Current uses for simulation

Example - Heat Shield for GE Power



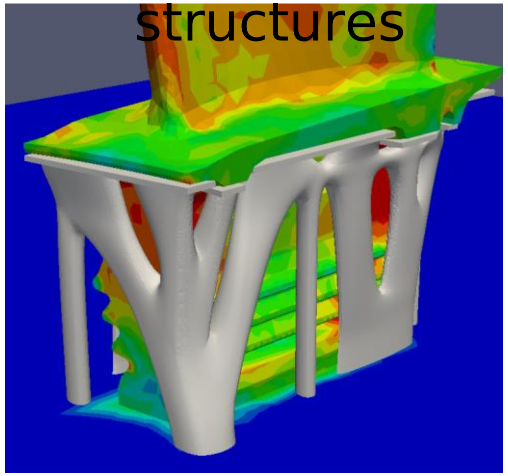




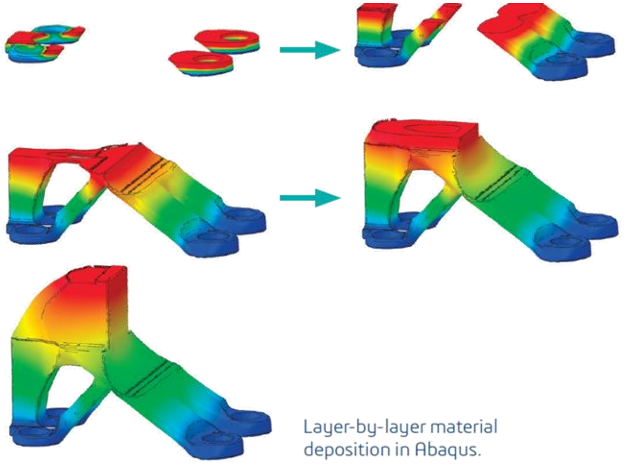
Work presented at NAFEMS Conference in Telford (UK) in June 2016 by Charles Soothill from GE Power

Future uses for simulation

Optimisation of support structures

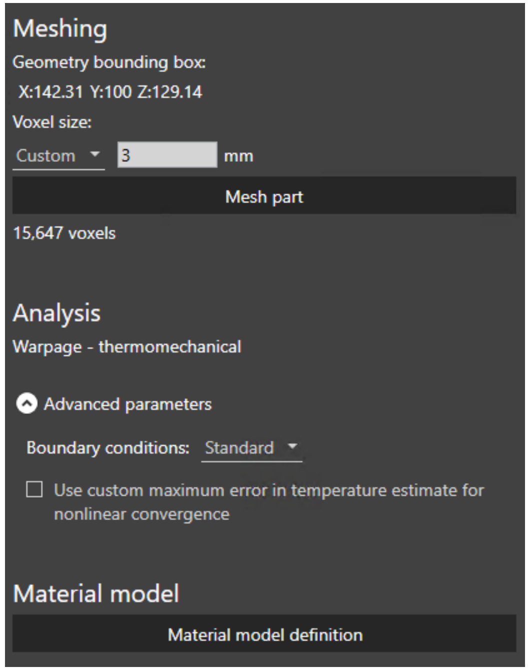


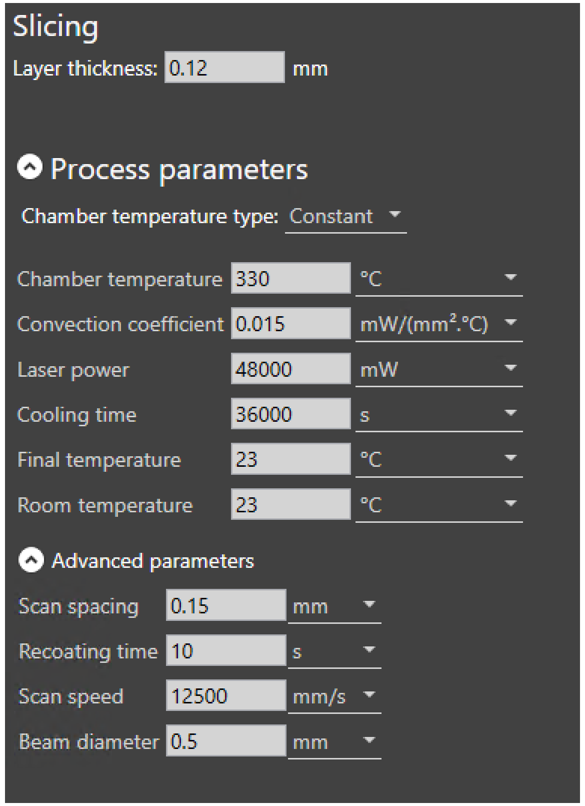
Thermal management of build

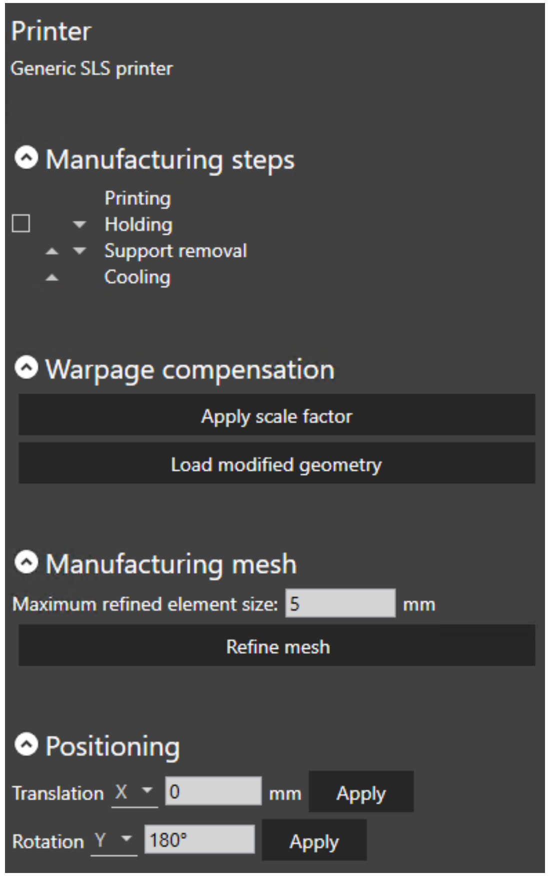


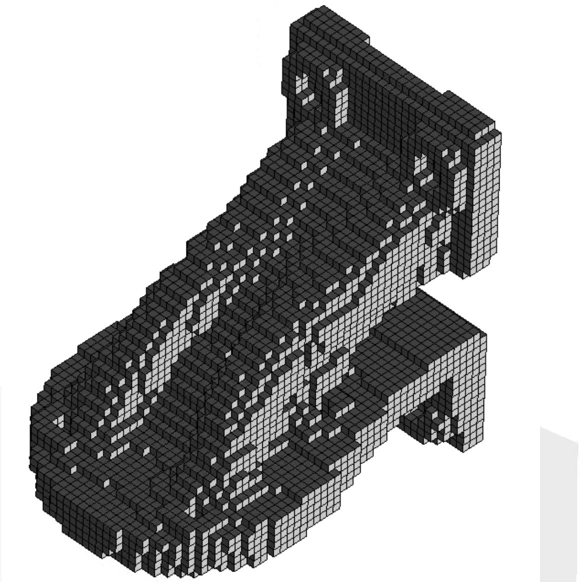
https://www.linkedin.com/pulse/can-simulation-help-advance-additive-manufacturing-technology-sett

Example: PBF-LB simulation setup

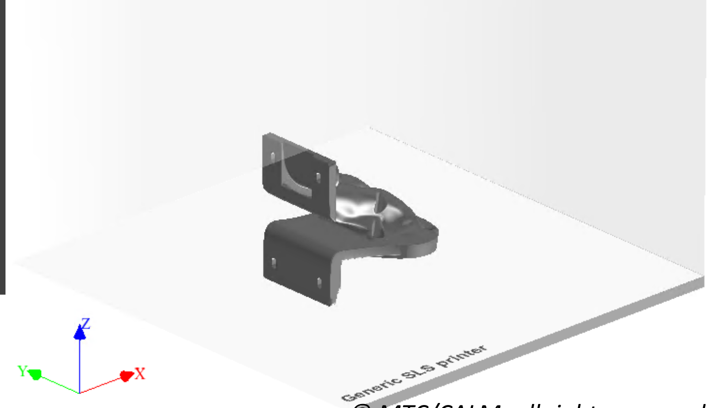








© MTC/CALM, all rights reserved.



© MTC/CALM, all rights reserved.

mtc Training

NATIONAL CENTRE ADDITIVE MANUFACTURING

Source:

Example: MEX simulation setup

Project review

Printer	ARBURG - freeformer 200-3X
Part	Marking Jig 3197988-D01-00
Units	MPa (t, mm, s, °C, N, MPa, mJ)
Part material	Updated-MC-INEOS-100-TVE-2.0_PP0_MTC
Supplier	MTC
Support material	AquaSys-120-TVE-01
Supplier	MTC
Analysis	Warpage - thermomechanical
Relaxation effect	included
Mesh	129,080 voxels

Process parameters

Chamber temperature type: Constant

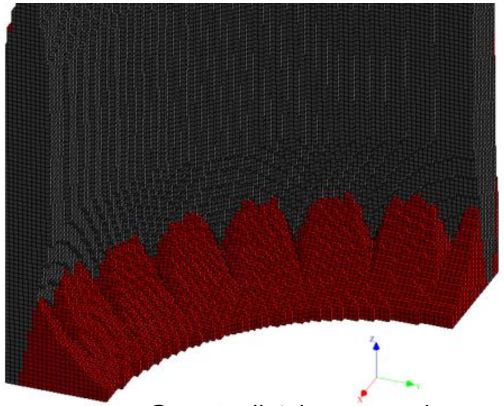
Chamber temperature	60	°C
Extrusion temperature	245	°C
Extrusion temp. (supports)	195	°C
Convection coefficient	15	W/(m².°C)
Holding time	1800	s
Cooling time	5400	s
Final temperature	40	°C
Room temperature	23	°C

Printer

ARBURG - freeformer 200-3X

Manufacturing steps

- Printing
- Holding
- Cooling
- Support removal



© MTC, all rights reserved.

mtc Training

NATIONAL CENTRE ADDITIVE MANUFACTURING

Limitations

- A variety of material test data (thermal, mechanical) is usually required to commence simulation which can increase the initial cost
- Results are based on process parameters and material properties and generally require material data calibration after initial test prints
- Mesh sensitivity analysis is required to achieve accurate results
- Exported compensated STL meshes may require extensive repair before printing

Examples of commercial process simulation tools

Tool
Comsol Multiphysics
Hexagon MSC Digimat
ANSYS
Etc.

Summary

- This session highlighted the benefits of using AM process simulation
- Identified key types of simulations used for polymer AM processes
- The information shared should be taken as a guide

Co-funded by the
Erasmus+ Programme
of the European Union