

Leveraging Generative Design Technology to Enhance Product Design for Manufacturing

Adam James & Mason Myers

Product Specialist and Sr Implementation Consultant





About Adam

Technical Specialist, Moldflow

Adam studied Plastics and Composites Engineering at Western Washington University and has gained exposure to a variety of Autodesk products including Moldflow, Fusion 360, and Netfabb. His experience revolves around product design for mass manufacturing, additive manufacturing, and injection molding simulation/analysis. Adam currently specializes in Moldflow at Autodesk and has been doing so for over one year now.



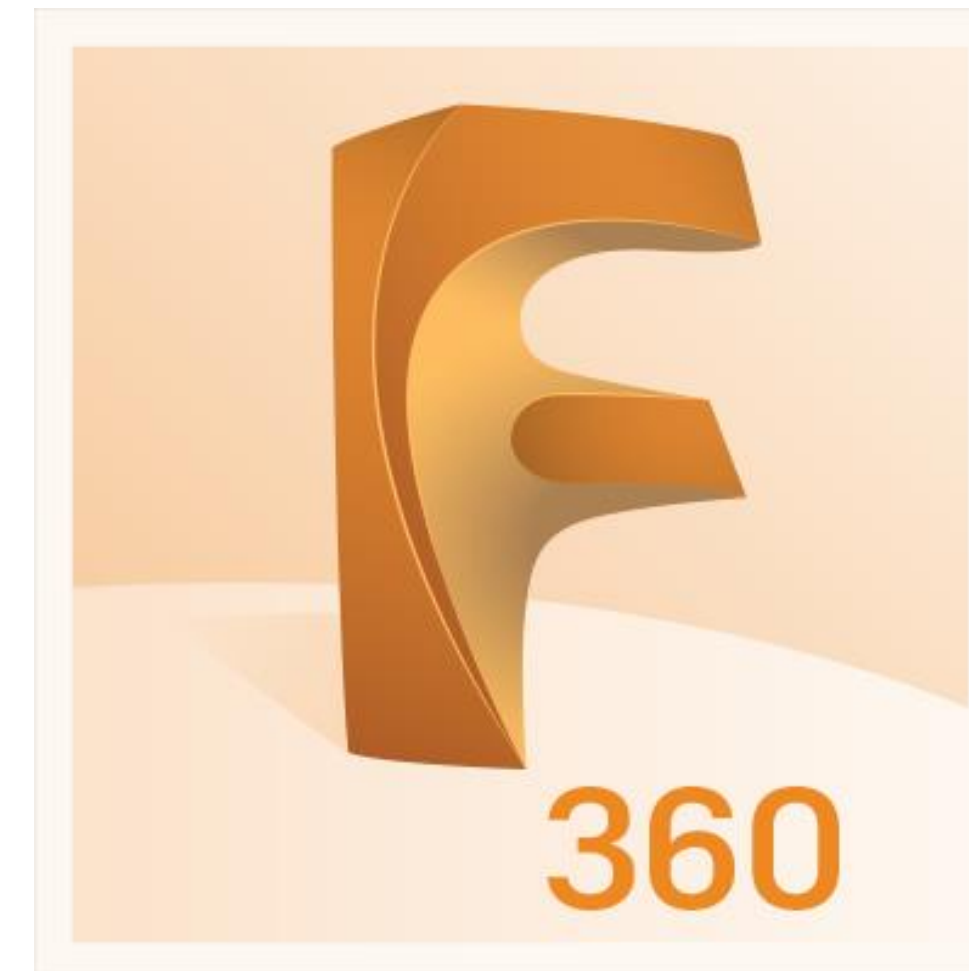
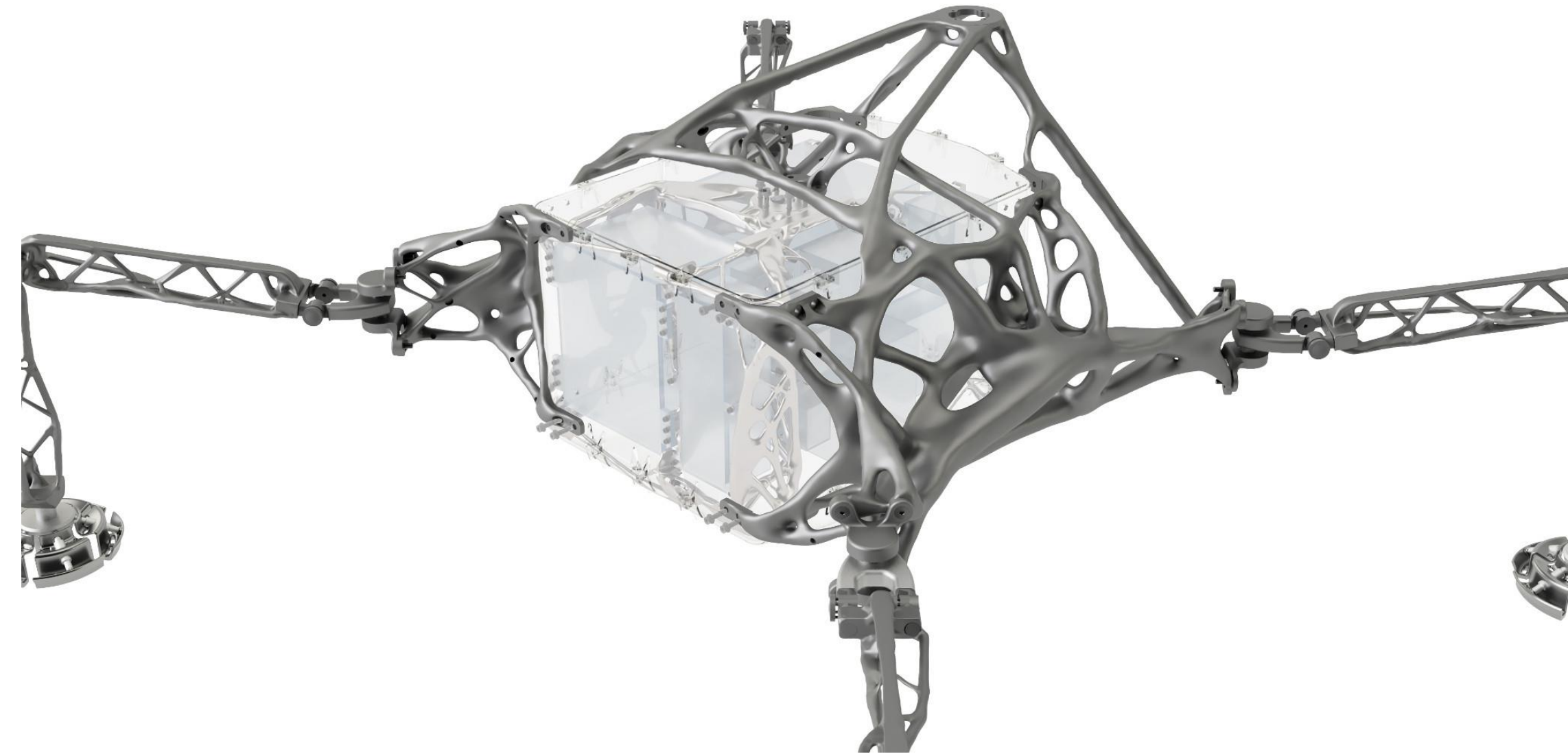
About Mason

Senior Implementation Consultant, Moldflow

Mason is a degreed plastics engineer from Penn State and started using Autodesk Moldflow in 2003. He has experience with both thermoplastic and thermosetting materials, part/mold design, and processing. Mason currently helps Autodesk customers implement and adopt Moldflow simulation tools.

Benefits of Generative Design

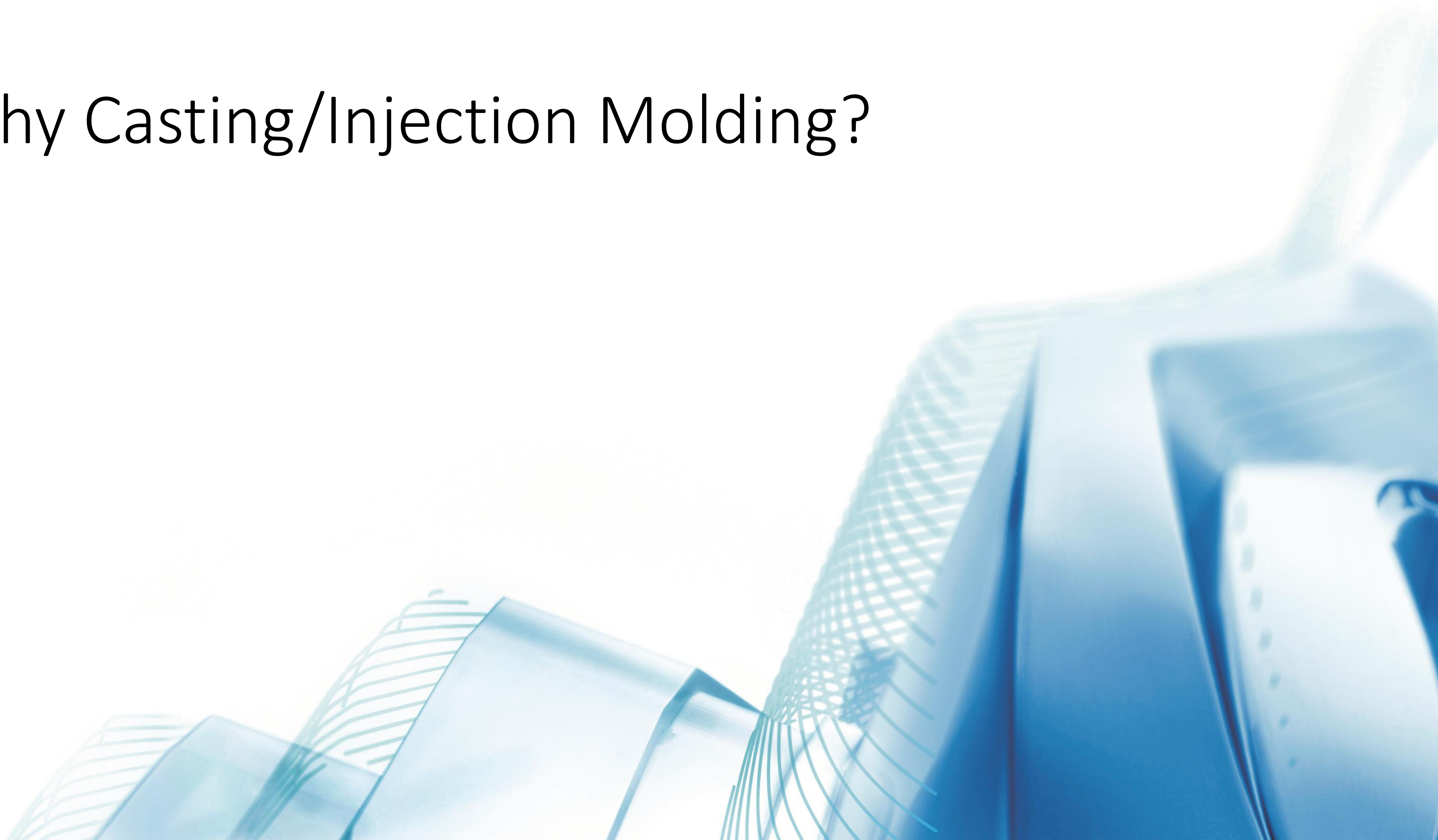
- Increased productivity with thousands of iterations
- Increased creativity with algorithms generating non-traditional and organics forms unimaginable to humans
- Embedded design for manufacturability features in one platform allows product designers and manufacturing collaboration earlier in the design cycle



Introduction to Generative Design



Why Casting/Injection Molding?



A photograph of an industrial manufacturing environment. In the foreground, there is a large orange machine with a yellow safety frame and a transparent window showing internal components. To the left, a grey control unit sits on an orange stand, connected by various cables. In the background, other industrial equipment and a robotic arm are visible. A large orange panel on the right side of the image contains white text.

325.69
BILLION



***MORE* IS INEVITABLE**



GENERATIVE = LESS

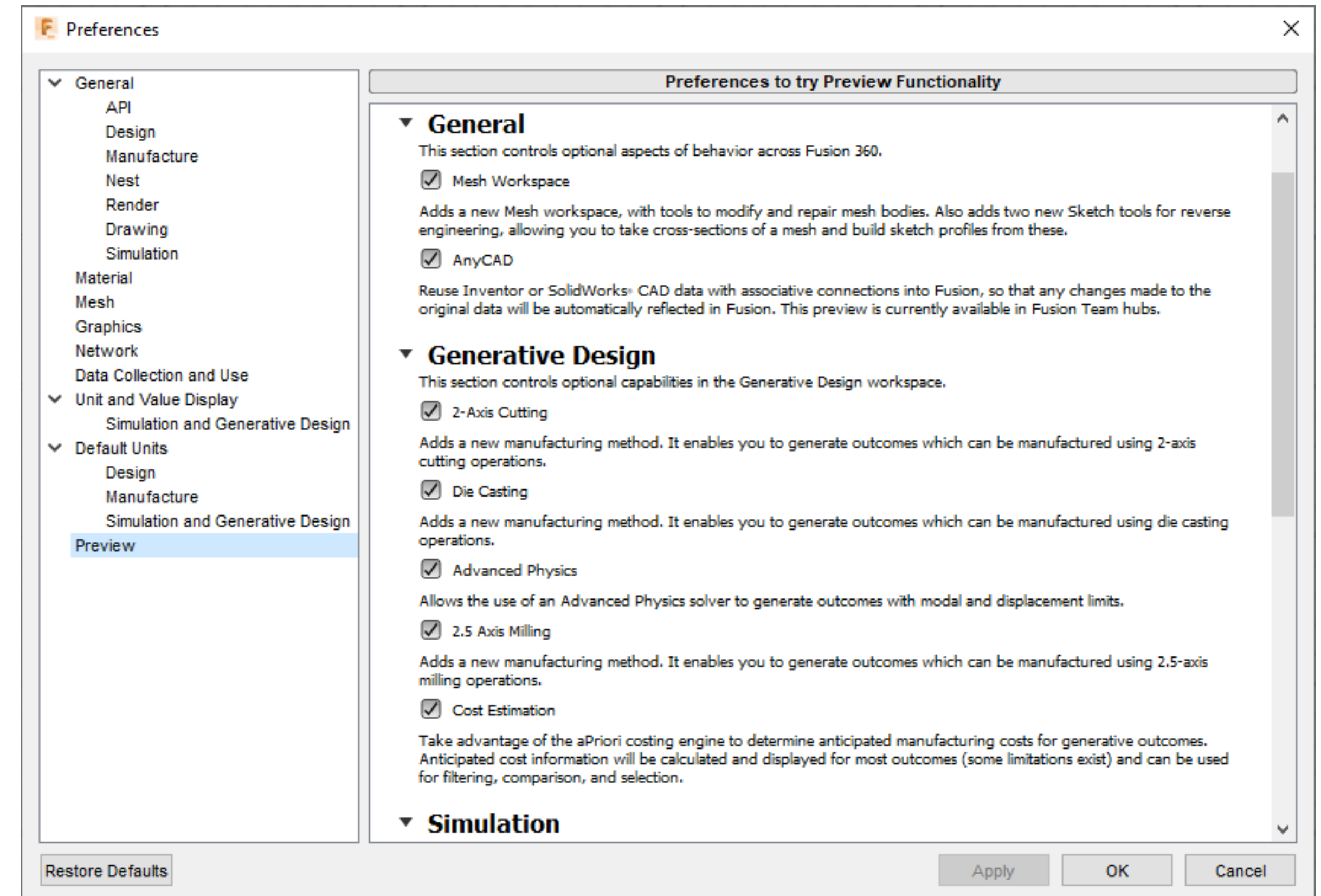
Additive has taken the spotlight

- New features allow incorporation of mass manufacturing constraints
- Additive is great for one off products
- Die Casting and Injection Molding lead the industry in high volume products



Fusion 360 Tech Preview

- New UI toolbar
- New Icons
- Generative Design Updates
 - 2.5 Axis Milling
 - Die Casting
 - Cost Estimation
 - Outcome Navigation in Explore Space



Generative Design Best Practices





Original Geometry

- Door handle design intended for die casting
- Starting point
- Identify areas to reduce material consumption
- Identify preserve geometry

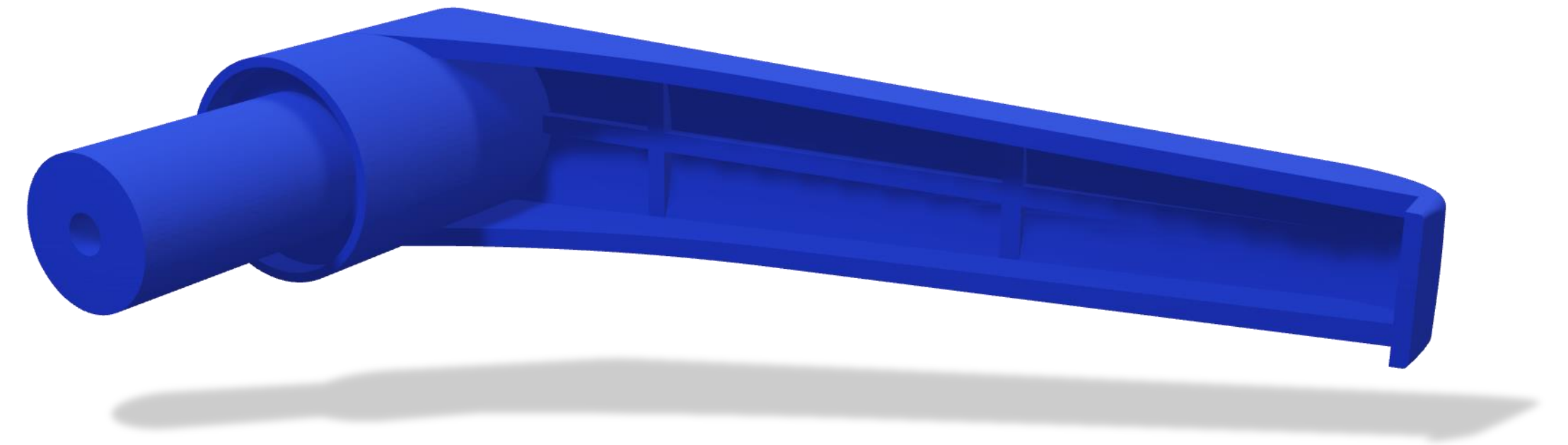


Figure 1: Original 3D model

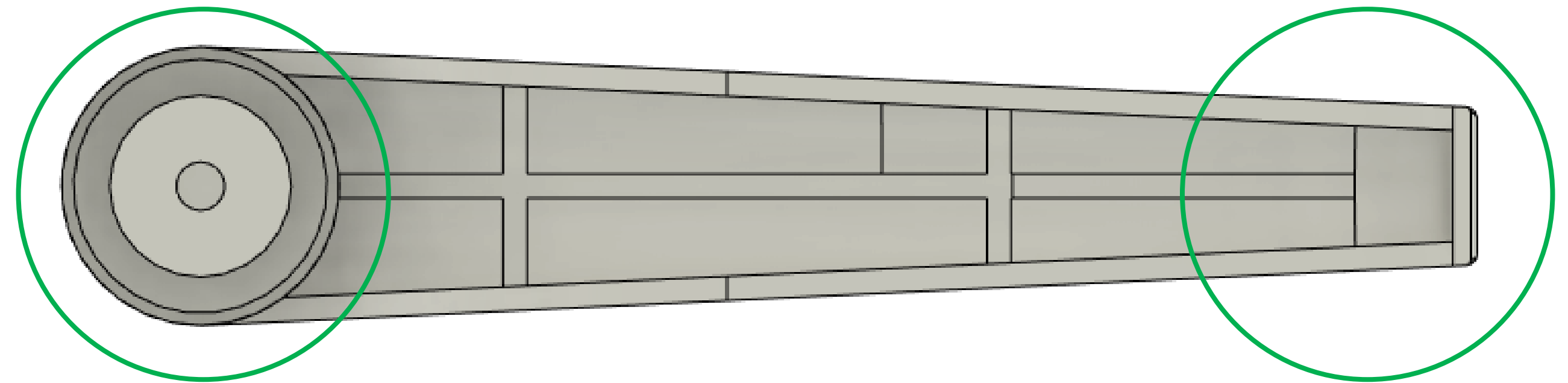


Figure 2: Areas of preserve geometry

Geometry Removal

- Remove geometry using simple extrude cut command
- Ensure Draft Angles exist on original geometry
- Identify potential problem areas
 - Wall Thickness
 - Suitability for Die Casting
- Leave geometry with forces acting on them



Figure 3: Preserve Geometry 3D model



Figure 4: Generative Design Space

Obstacle Geometry

- Inverse design approach
- Understand where material is not needed
- Walls to confine AI to work in
- Simplistic geometry
- Know that you can always touch up later
- GD can only work where geometry is nonexistent

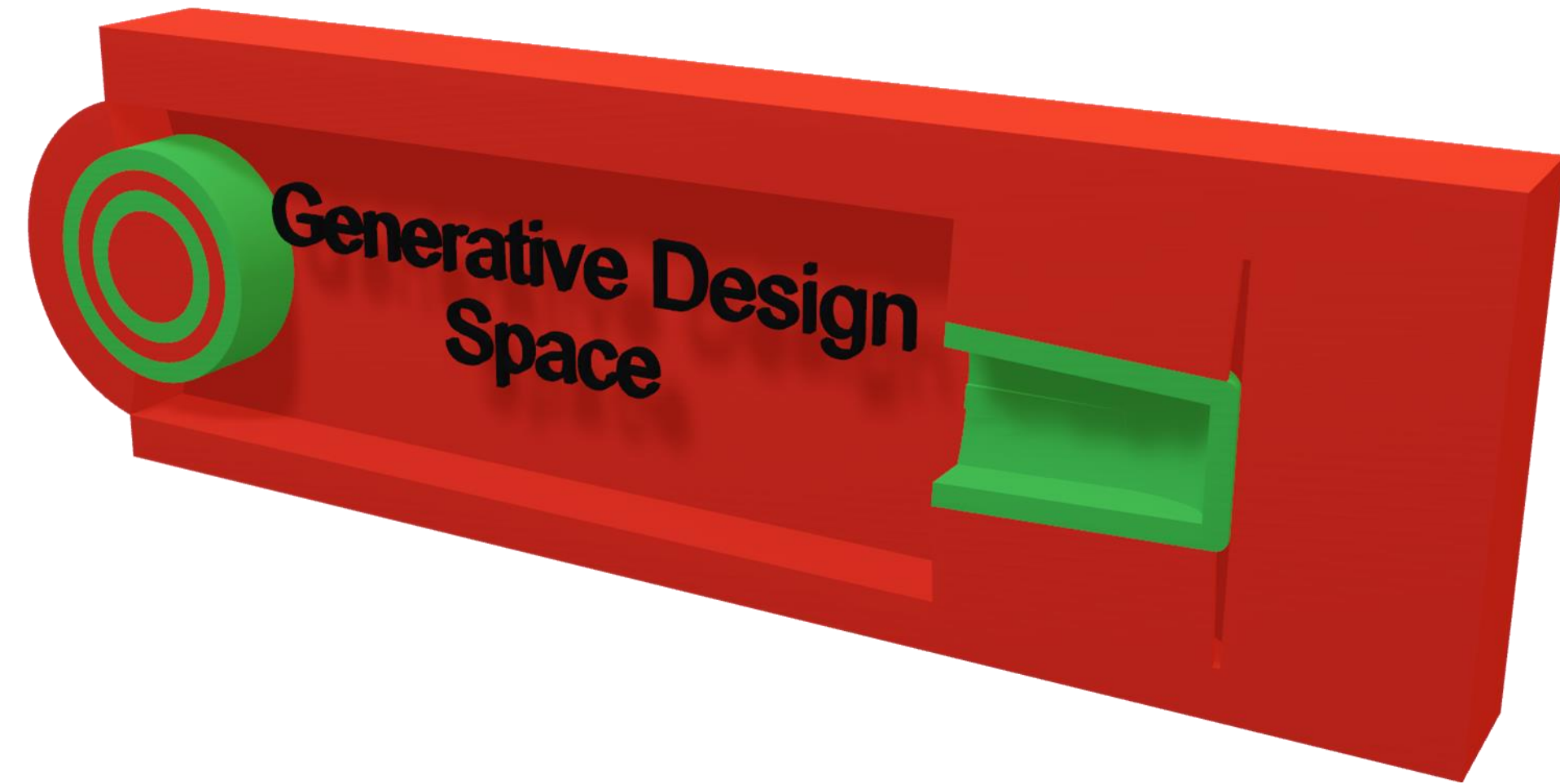


Figure 5: Obstacle Geometry Section View

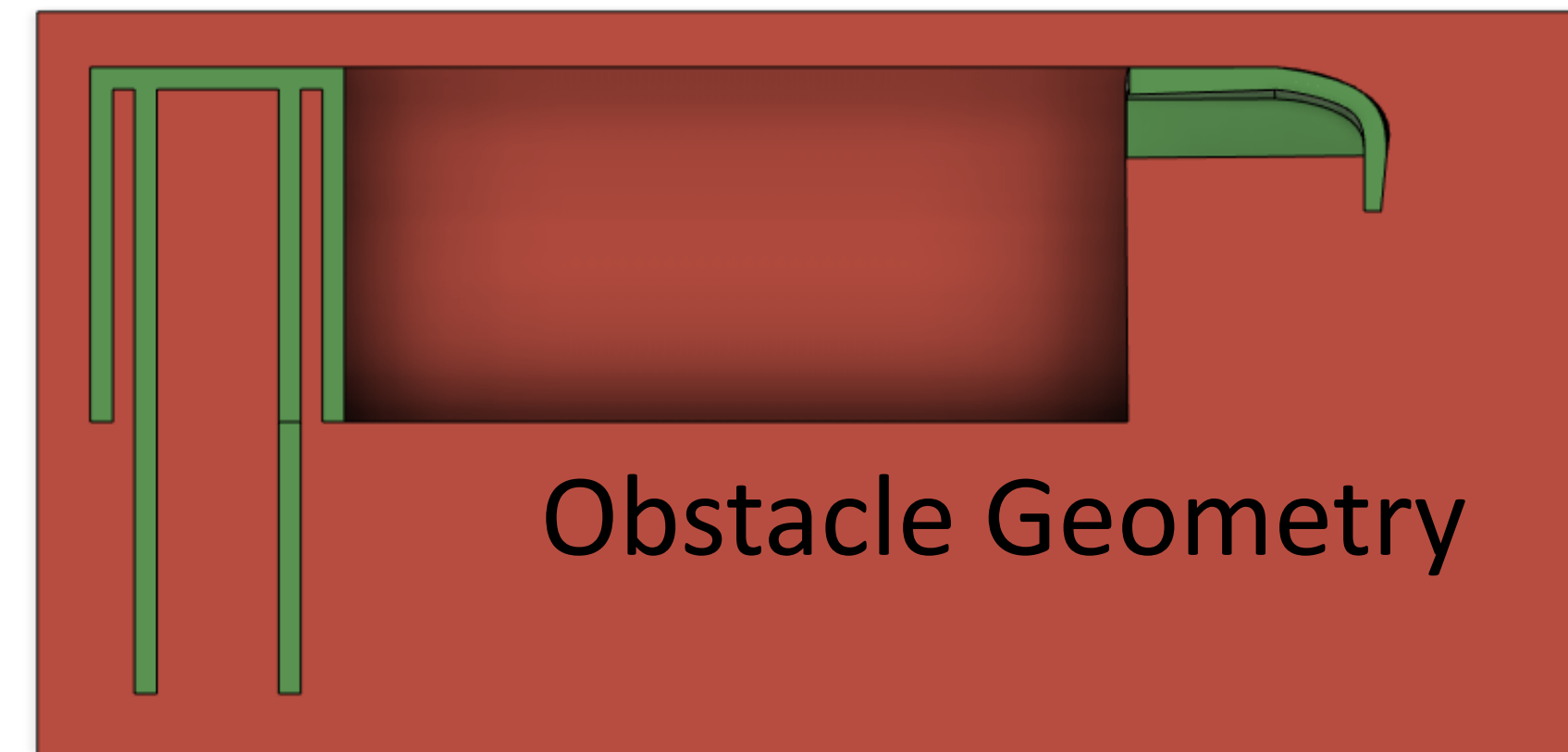


Figure 6: Obstacle Geometry Top Down

Study Settings

- Decrease voxel mesh size
- If Synthesis resolution is not closer to Fine:
 - GD solver behaves inversely
 - Addition of material
 - Lack of subtraction of material

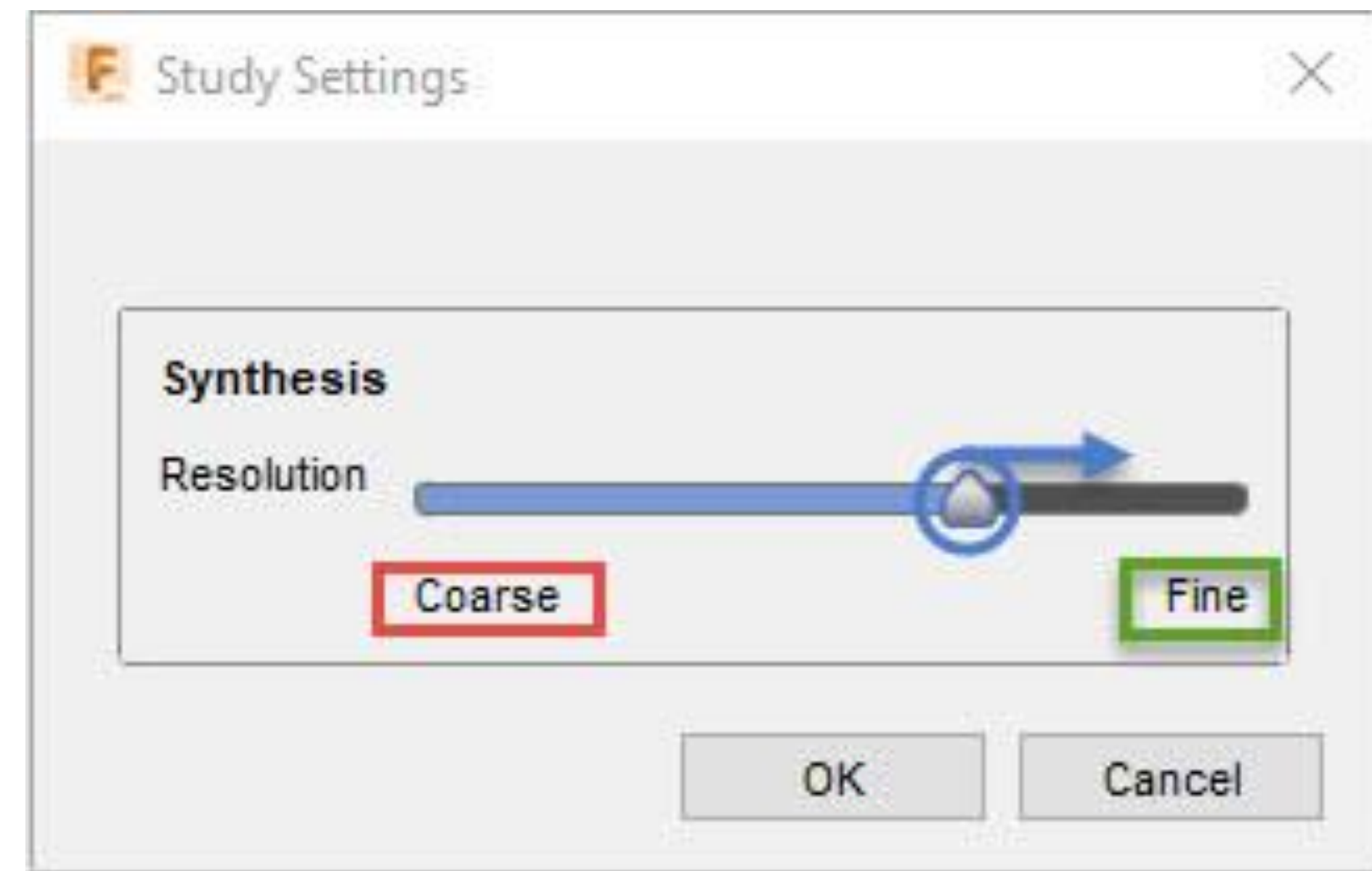
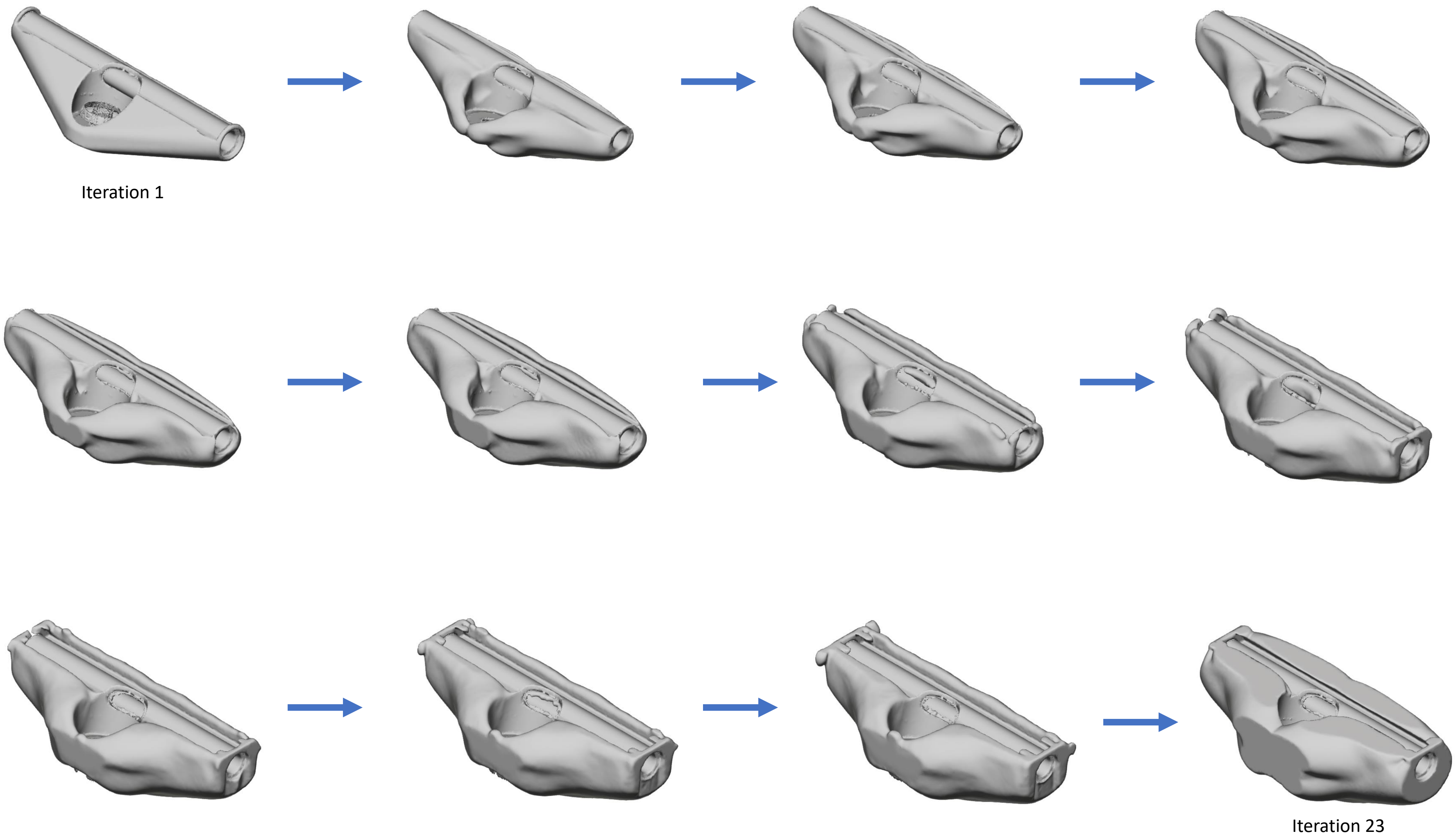


Figure 7: Synthesis Resolution Scale

Why is Synthesis Resolution Important?



Do we need say more?



Figure 8: Coarse Resolution

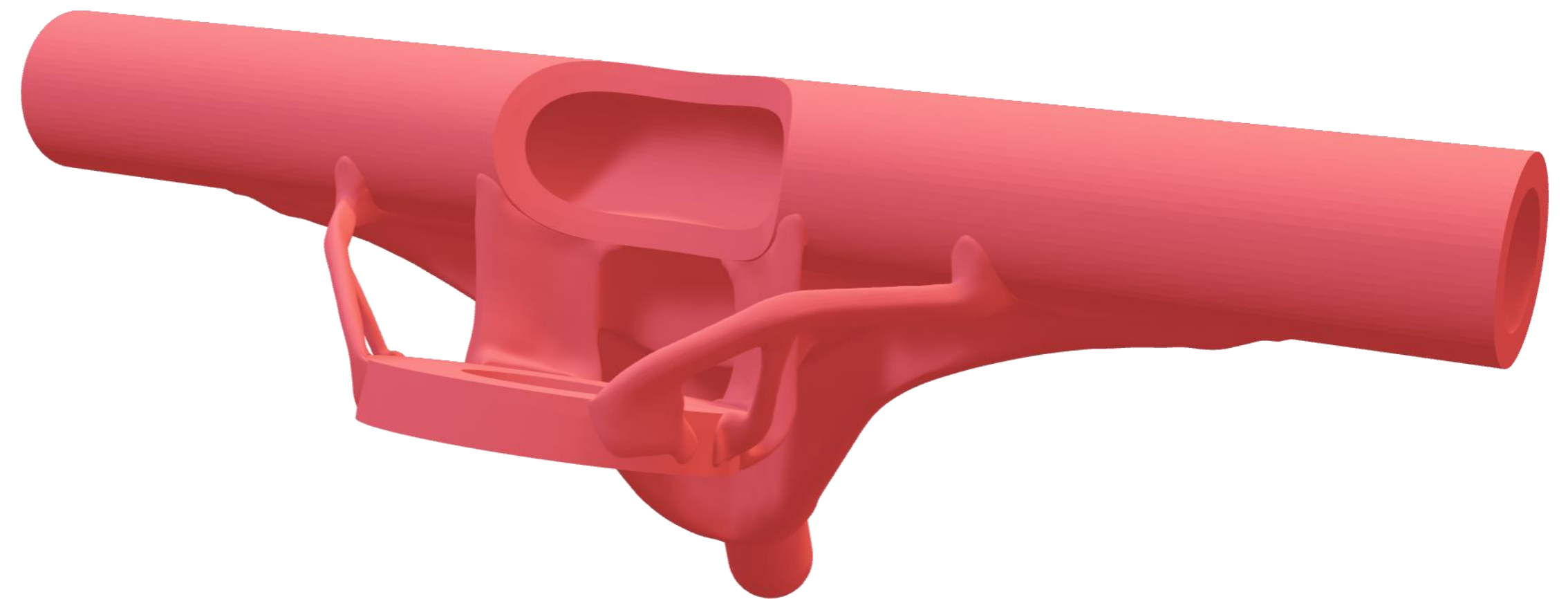
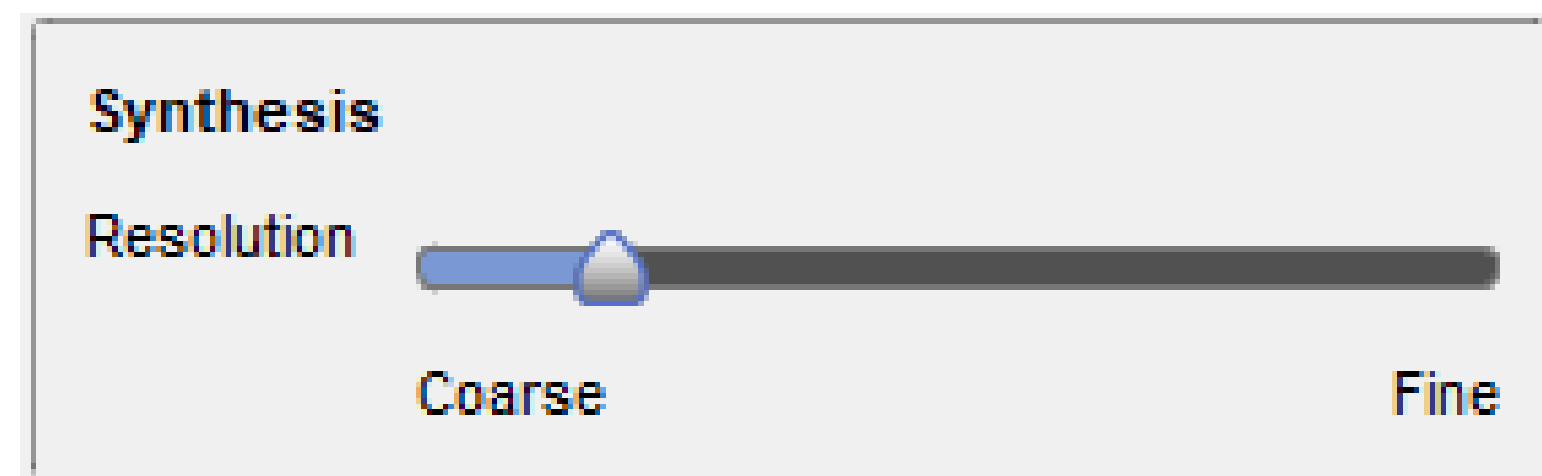
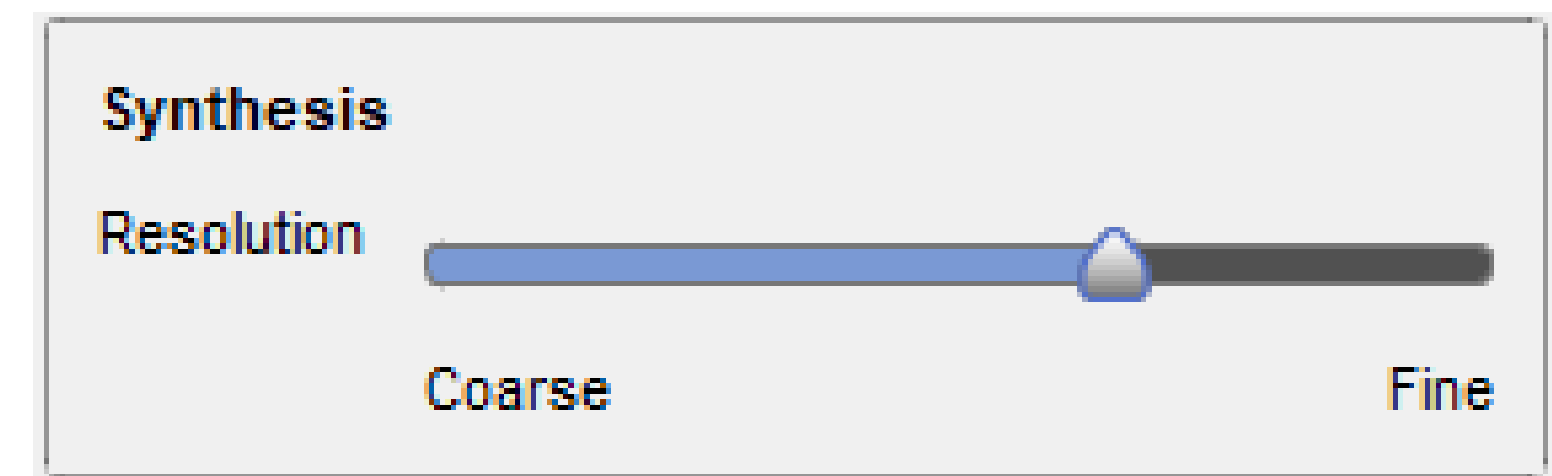


Figure 9: Fine Resolution



Loading and Constraints

- Forces applied to preserve geometry
- At least one constraint per load case
- Ensure direction of gravity is correct
- Loads included:
 - Torsion
 - Tension
 - Compression

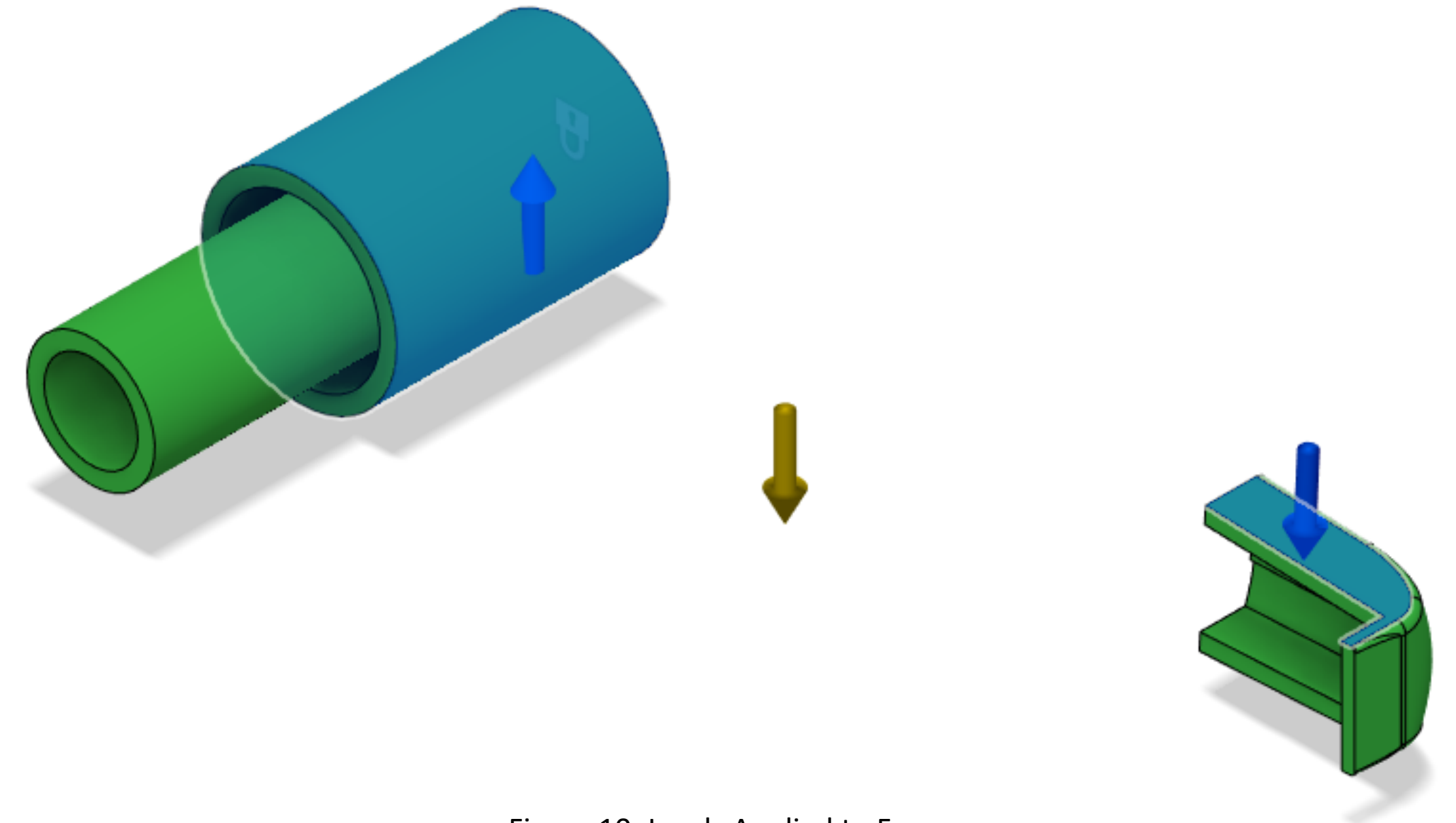


Figure 10: Loads Applied to Faces

Manufacturing

- De-select Manufacturing options to save time
- Unrestricted
- Additive
- Milling
- 2-axis Cutting
- Die Casting

This dialog box shows settings for 2-axis Cutting and Die Casting. The '2-axis Cutting' section has 'Cutting Direction' set to Z. The 'Die Casting' section has 'Ejection Direction' set to Y, 'Minimum Draft Angle' at 3.0 deg, 'Minimum Thickness' at 1.75 mm, and 'Maximum Thickness' at 3.00 mm.

Section	Property	Value
2-axis Cutting	Cutting Direction	X Y Z
Die Casting	Ejection Direction	X Y Z
	Minimum Draft Angle	3.0 deg
	Minimum Thickness	1.75 mm
	Maximum Thickness	3.00 mm

Buttons: OK, Cancel

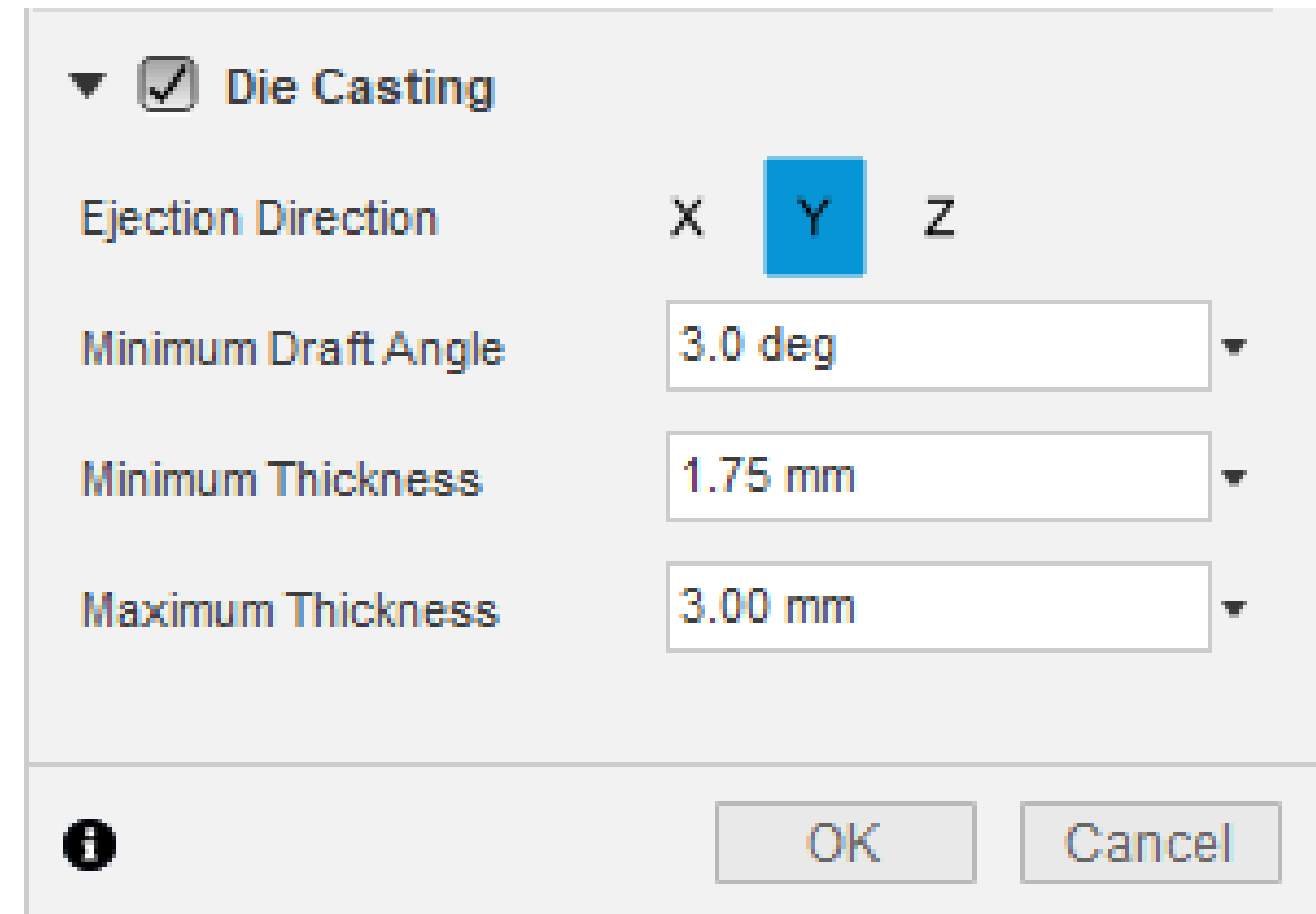
This dialog box shows settings for Additive and Milling. The 'Additive' section has 'Overhang Angle' at 45.0 deg and 'Minimum Thickness' at 3.00 mm. The 'Milling' section has 'Configuration 1' set to 3-axis, 'Tool Direction' set to Y-, 'Include all six directions' unchecked, 'Minimum Tool Diameter' at 10.00 mm, 'Tool Shoulder Length' at 40.00 mm, and 'Head Diameter' at 60.00 mm.

Section	Property	Value
Additive	Overhang Angle	45.0 deg
	Minimum Thickness	3.00 mm
Milling	Configuration 1	3-axis
	Tool Direction	X+ Y+ Z+ X- Y- Z-
	Include all six directions	<input type="checkbox"/>
	Minimum Tool Diameter	10.00 mm
	Tool Shoulder Length	40.00 mm
	Head Diameter	60.00 mm

Figure 11: Manufacturing Settings

Die Casting

- Choose ONE ejection direction which pertains to the existing preserve geometry
- Deviation from minimum to maximum thickness in relation to wall thickness of preserve geometry



The image shows a software dialog box titled "Die Casting". It has a checked checkbox at the top left. Below it, there are four settings, each with a label and a value field. The "Ejection Direction" field has three buttons: "X", "Y" (which is highlighted in blue), and "Z". The other three settings are "Minimum Draft Angle" (3.0 deg), "Minimum Thickness" (1.75 mm), and "Maximum Thickness" (3.00 mm). At the bottom left is an information icon, and at the bottom right are "OK" and "Cancel" buttons.

Setting	Value
Ejection Direction	X Y Z
Minimum Draft Angle	3.0 deg
Minimum Thickness	1.75 mm
Maximum Thickness	3.00 mm

Figure 12: Die Casting Settings

Material Selection

- Maximum of 7 materials may be specified
- Wide variety of materials
- Only select materials worthy of including in solve
 - Saves time
 - Does not cost additional cloud credits
- Some materials do not contain valid properties for Generative Design

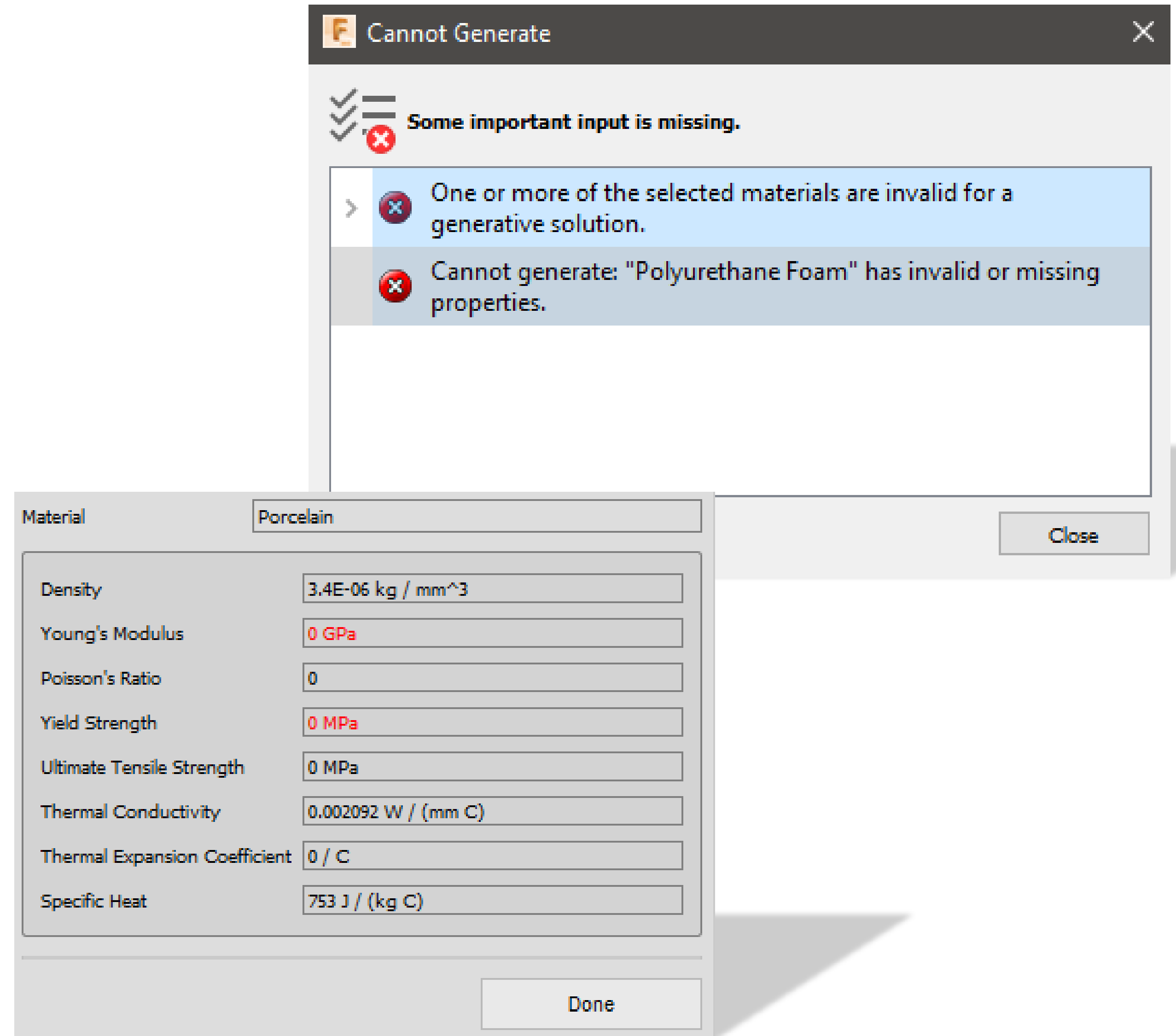


Figure 13: Invalid Materials

Pre-Check and Generate!

- Green means GO!
- Generate multiple design revisions
- 25 cloud credits to kick off Generation

Generate

STUDIES OF THE ACTIVE DOCUMENT


☐ Hide studies that cannot be generated


<input checked="" type="checkbox"/> Study	Status	Cloud Credits
<input checked="" type="checkbox"/> Generative Model 1 - Study 1 - Generative Generative	● Ready	25


CLOUD CREDITS

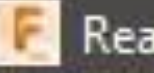
[BUY CREDITS](#) • [HISTORY](#) • [FAQ](#)


Required25

 GENERATE

 EXPLORE

 INSP

 Ready to Generate

 The study setup has all the information required.

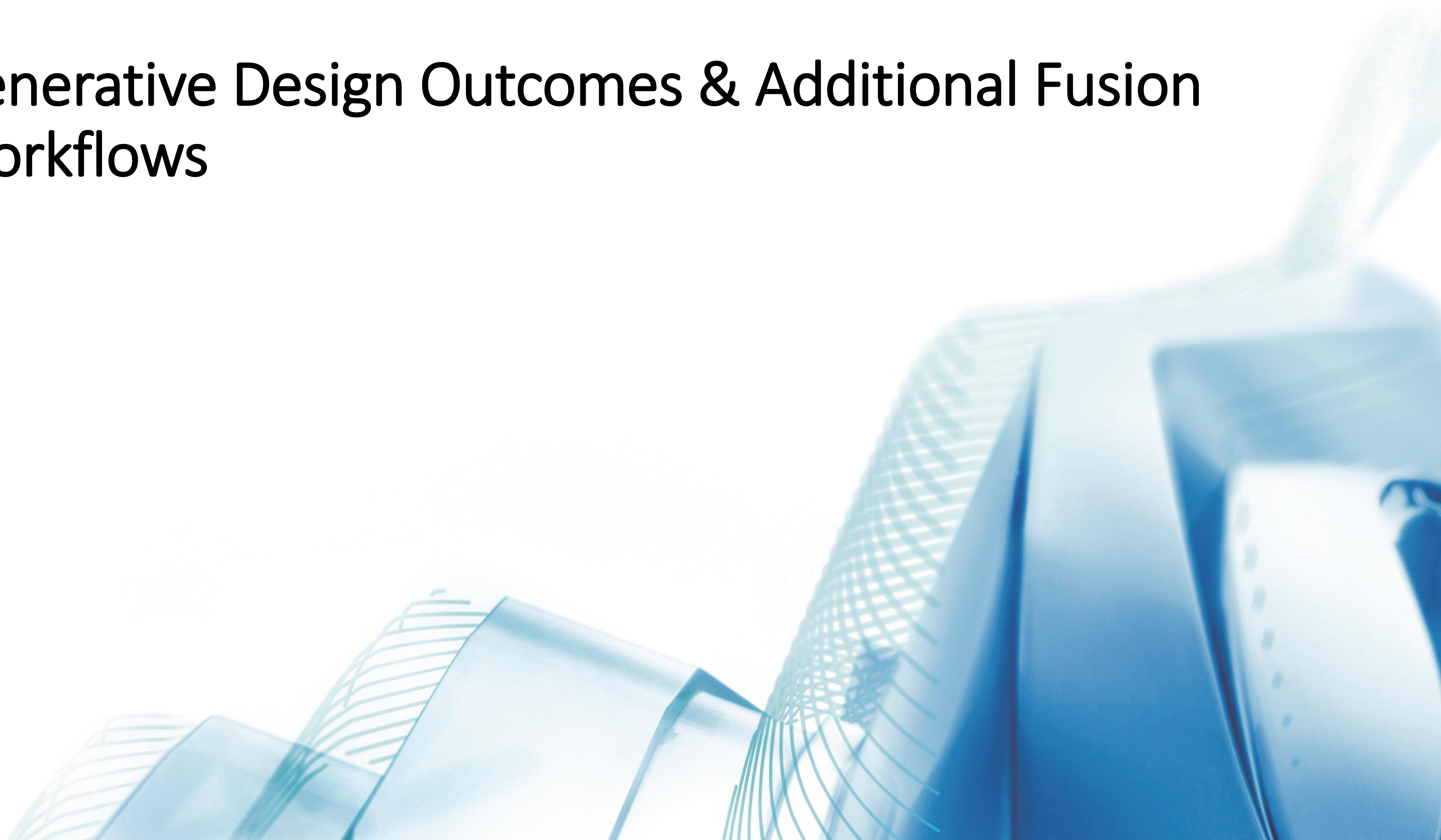
OK

The document is modified. A new version will be created before generating.

Generate 1 Study

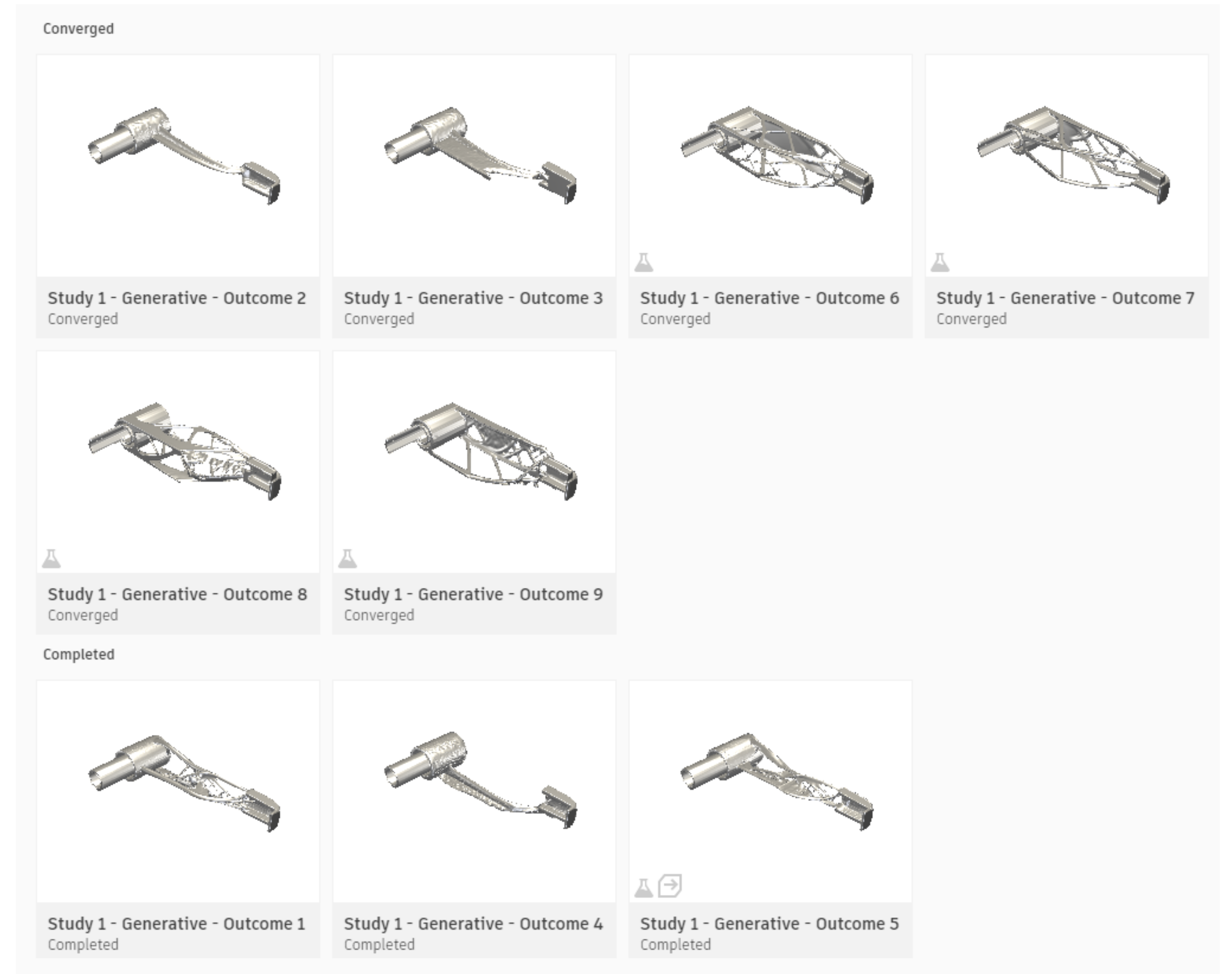
Close

Generative Design Outcomes & Additional Fusion Workflows



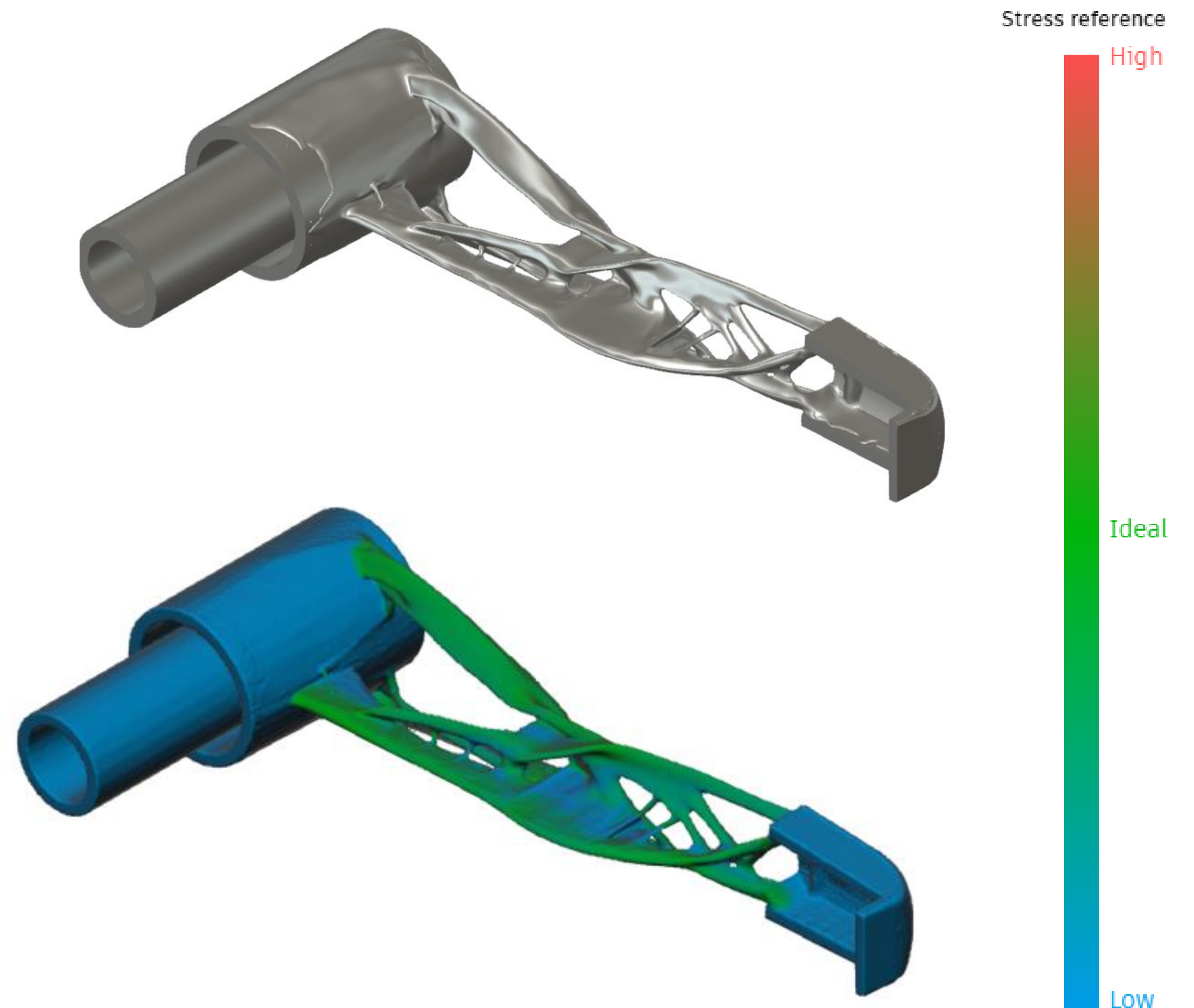
Explore Designs and Export

- Only Die Casting
- One material
- Faster solve times
- Results which only pertain to manufacturing methods of interest



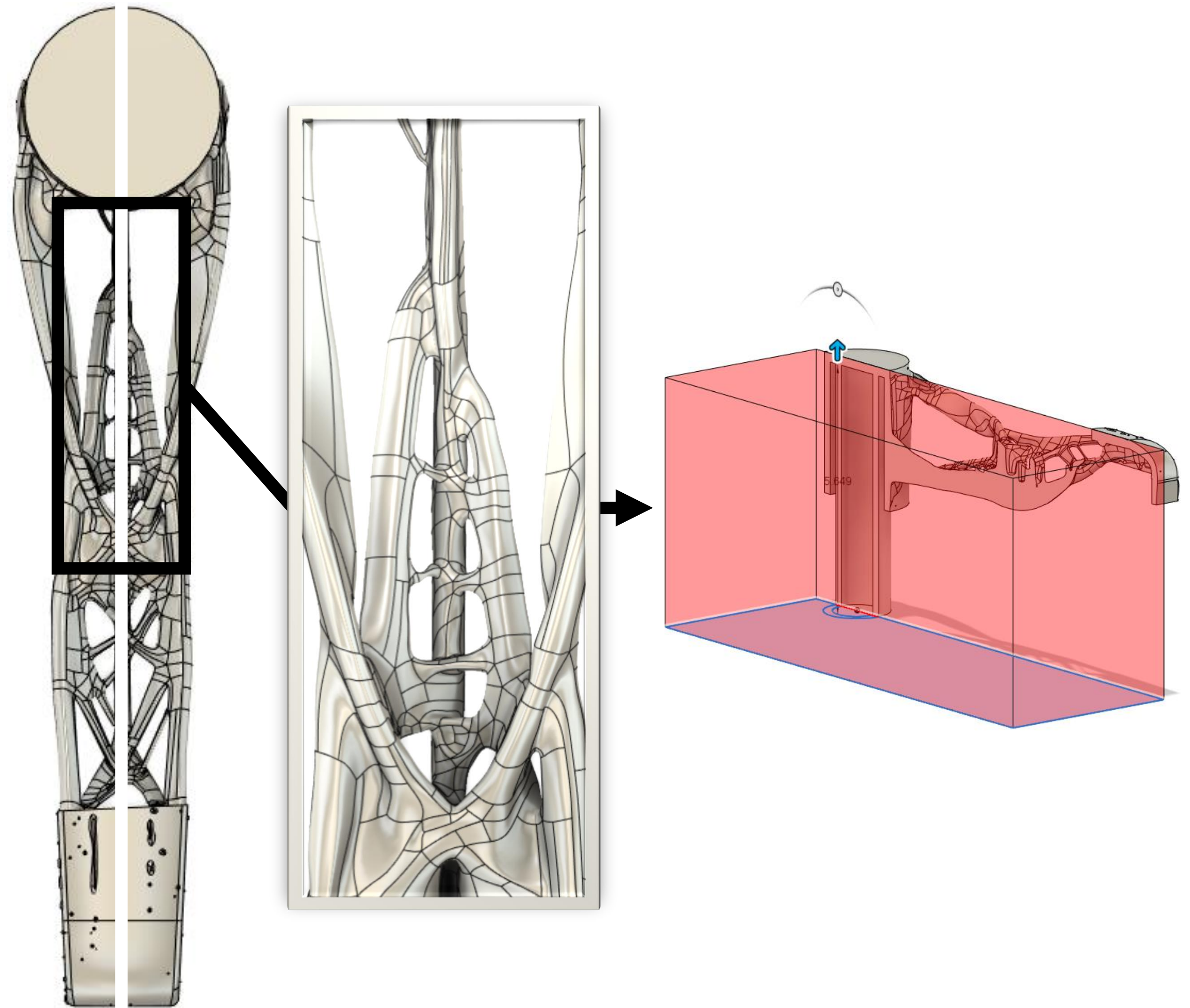
Create New Design from Outcome

- Find a design which satisfies stress reference criteria
- Aesthetically pleasing from a design perspective
- Creating new design from outcome presents a solid body ready for modification



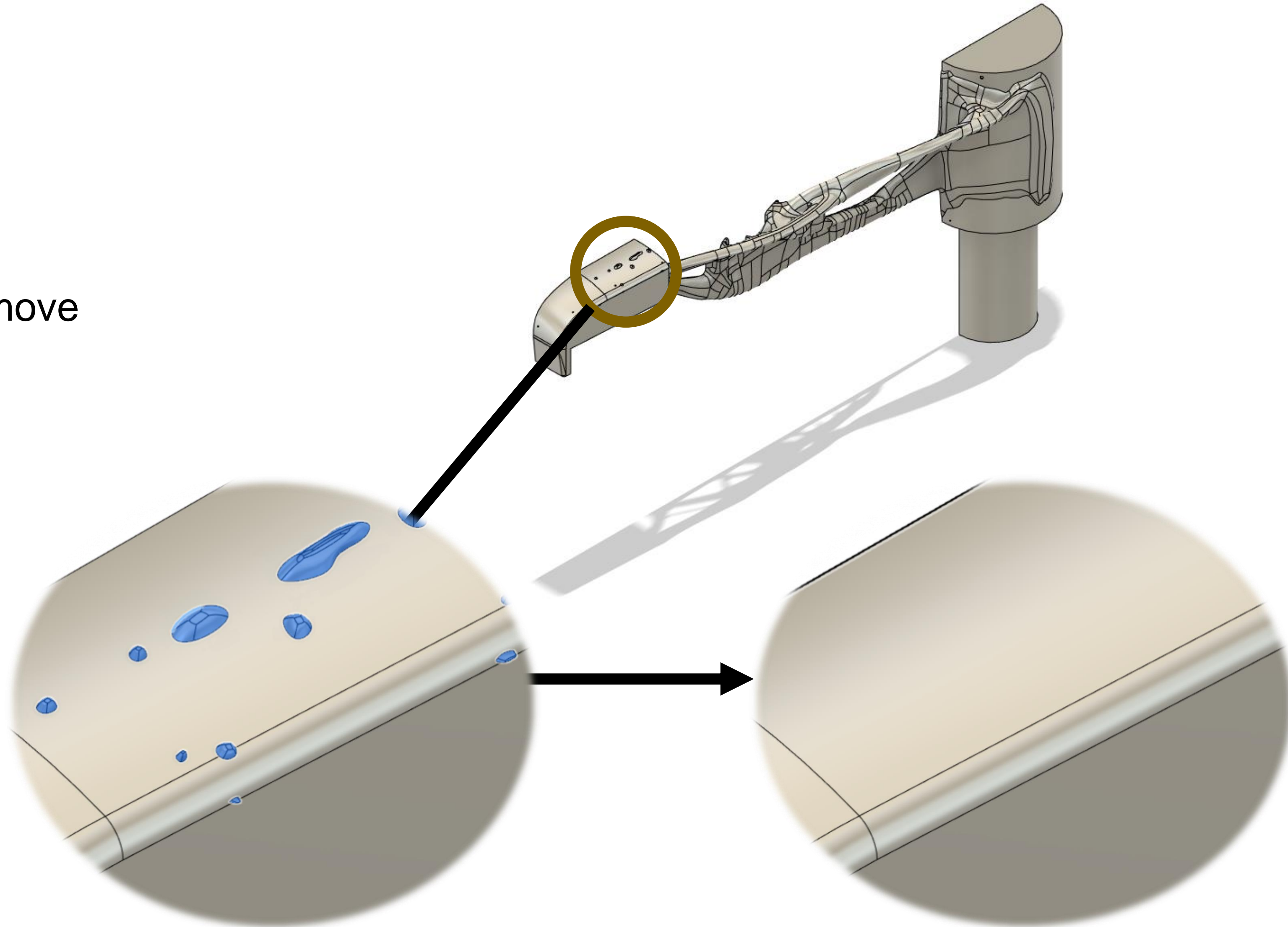
Symmetrical Design

- Implement on a product to product basis
- Not every product needs to be symmetric
- Easy secondary operations in Fusion 360



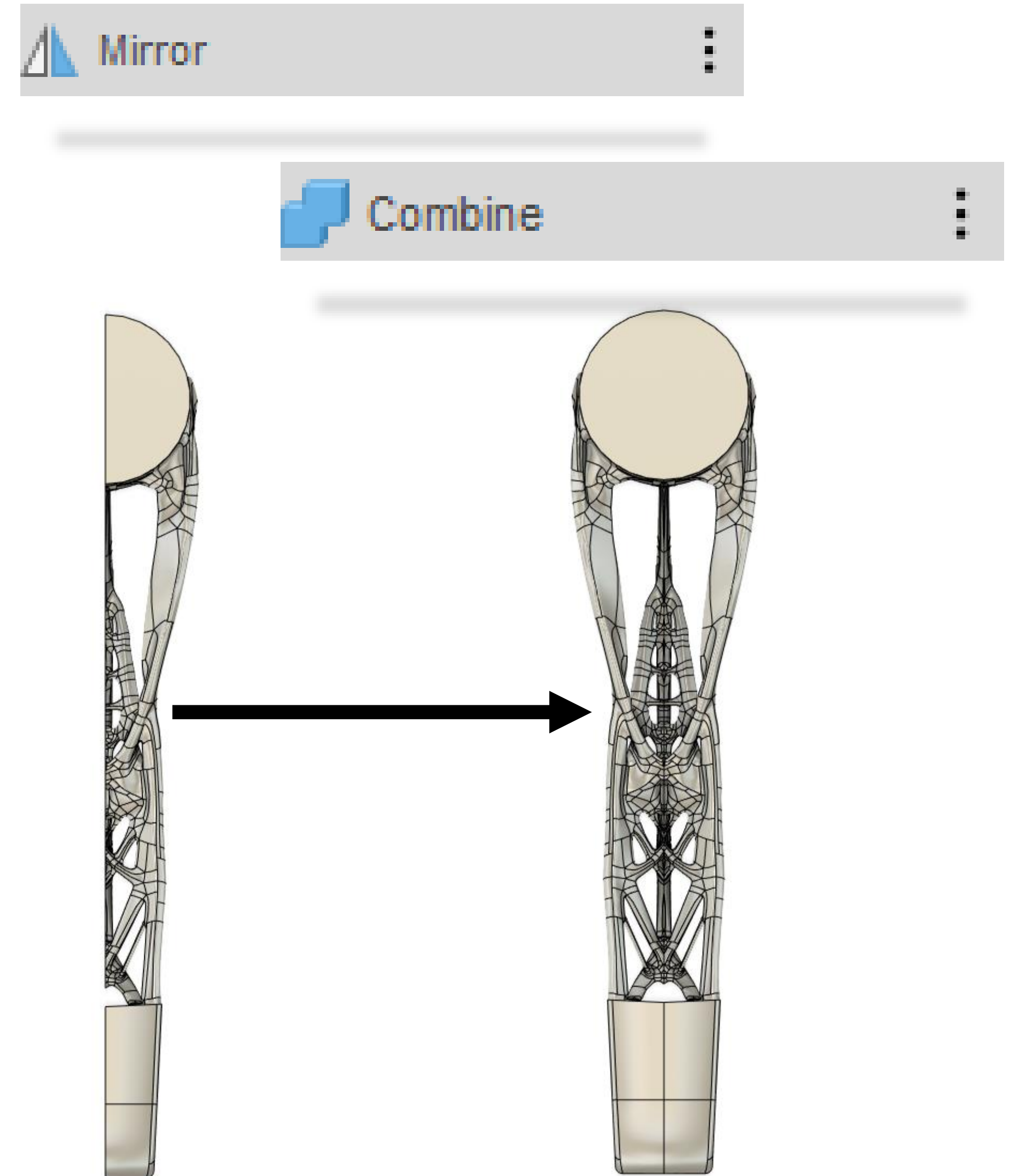
Modify Generatively Designed Geometry

- Delete un-needed surface geometry
- Simple ctrl+select and delete will remove features



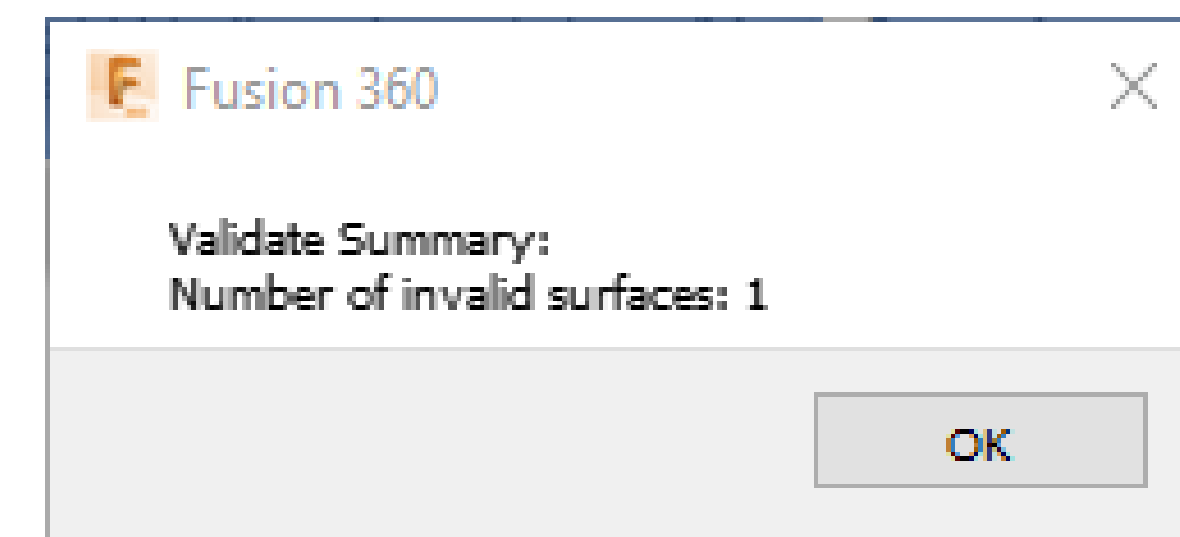
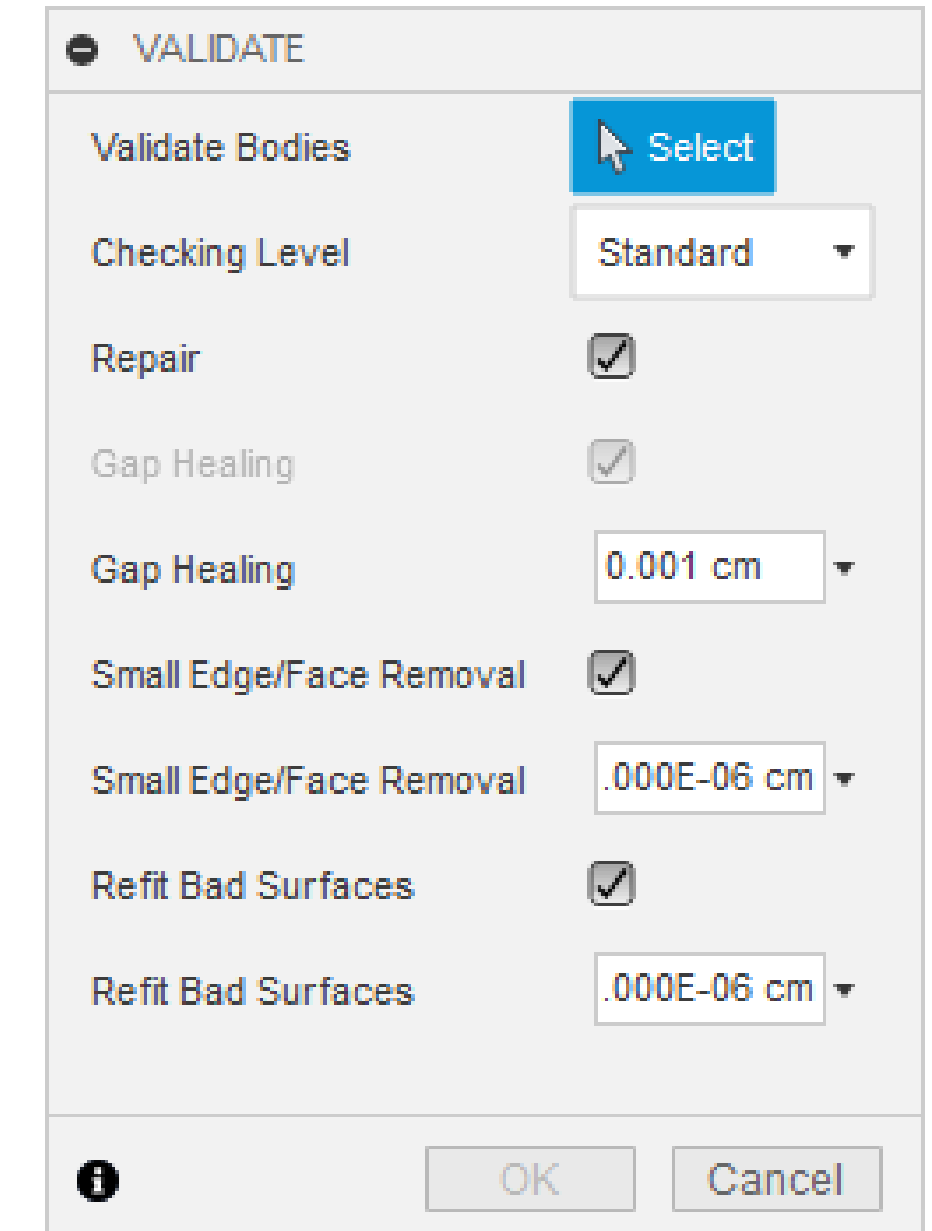
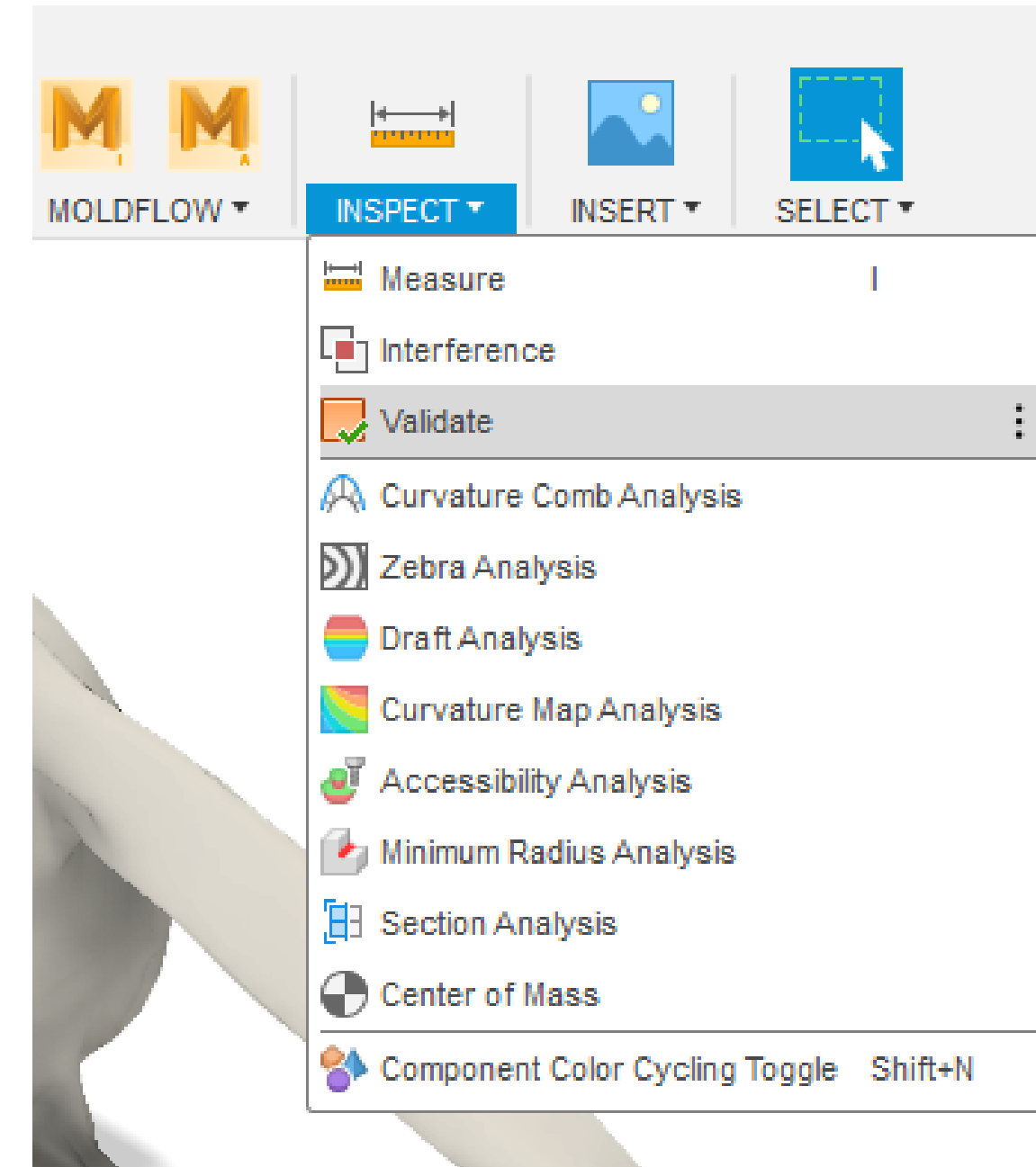
Mirror and Combine

- Mirror modified body
- Combine both bodies
- Ensure all un-needed surface geometry is nonexistent



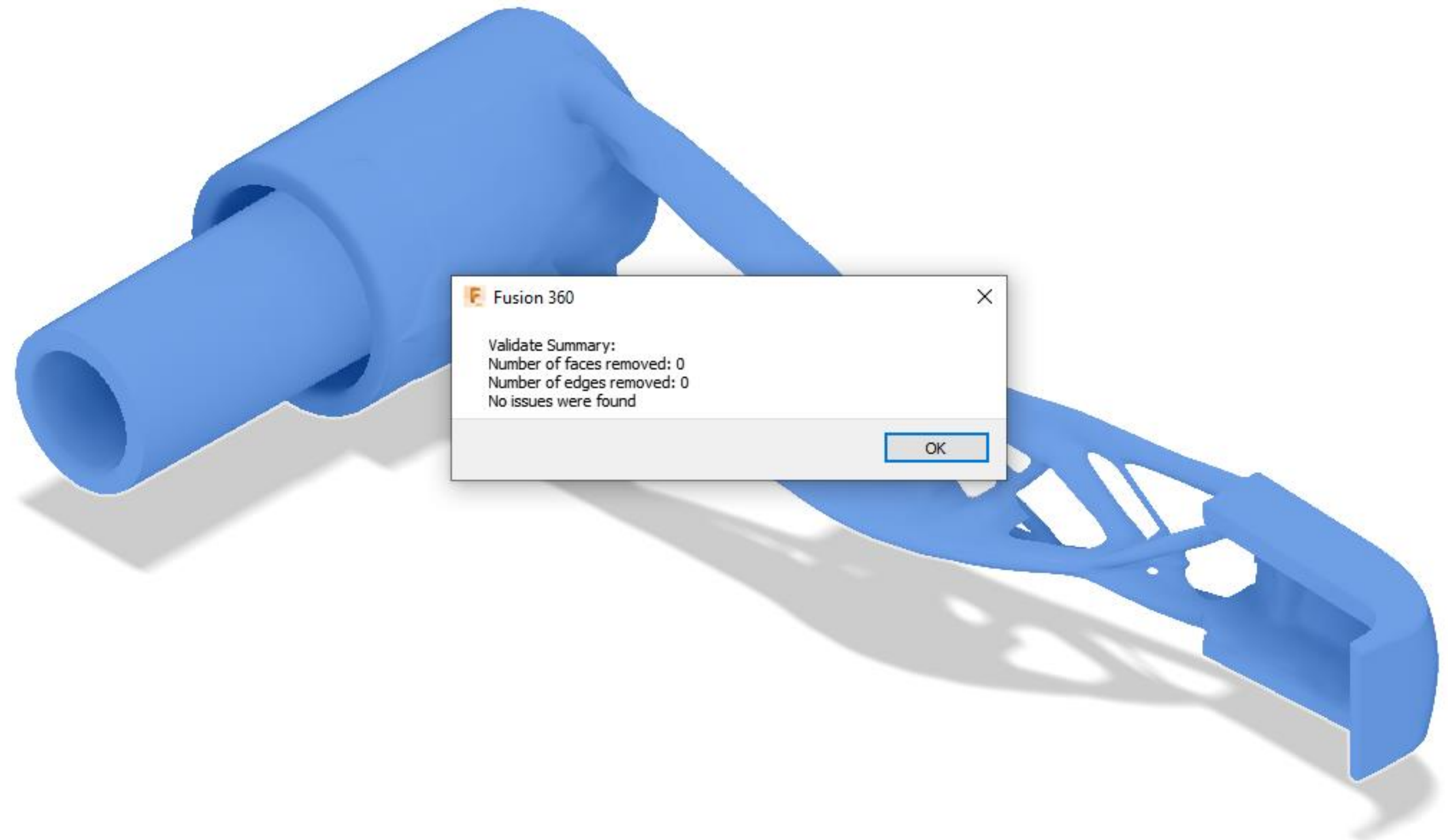
Validation & Repair in Fusion

- Validation and Repair Tools
 - *Solid – Inspect – Validate*
- Heal Overlapping Geometry
 - *Surface – Modify- Unstitch (all surfaces) – Delete surface*
 - *Surface – Create – Patch – Create new surface*
 - *Surface – Modify – Stitch (all surfaces)*

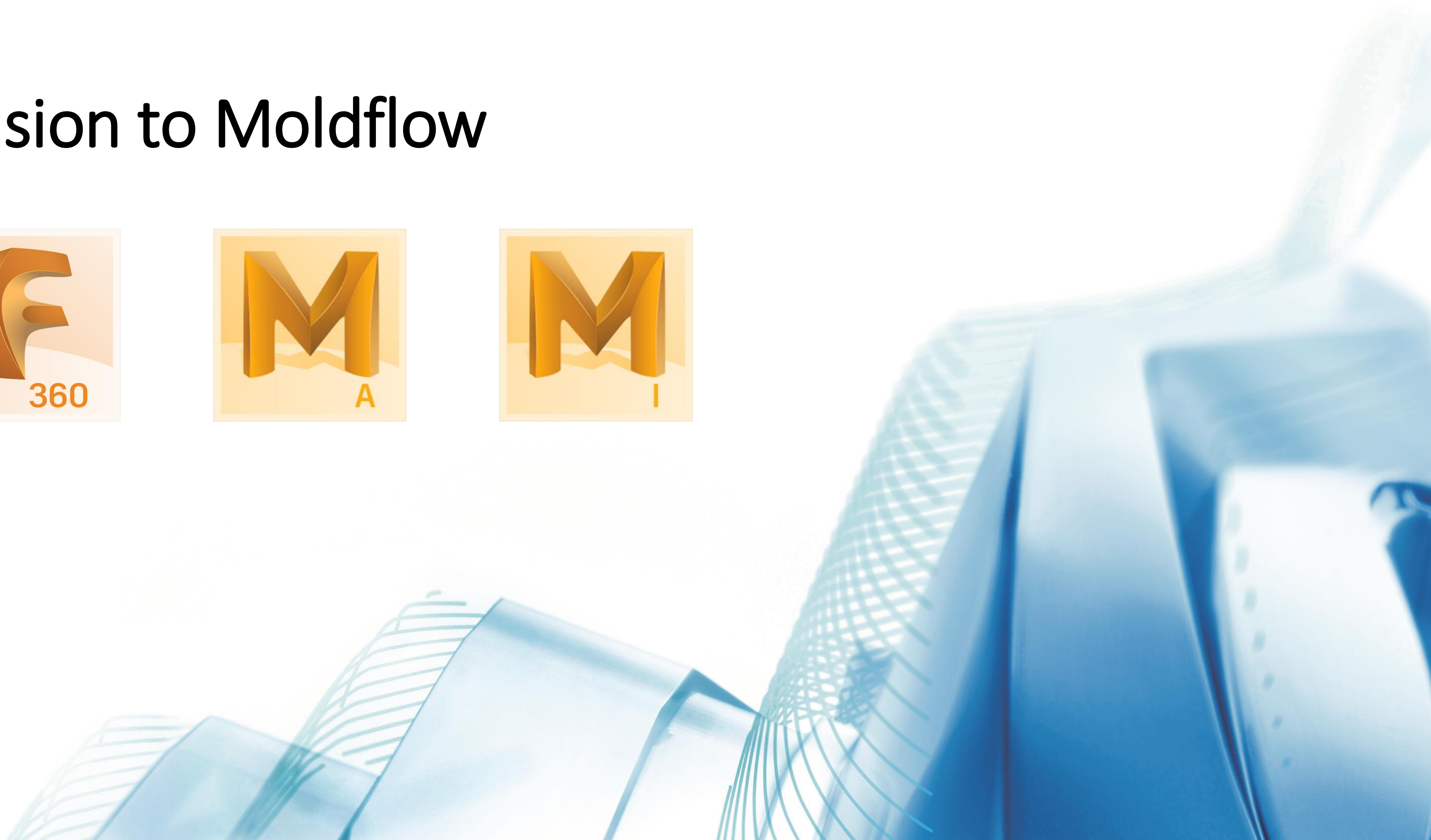
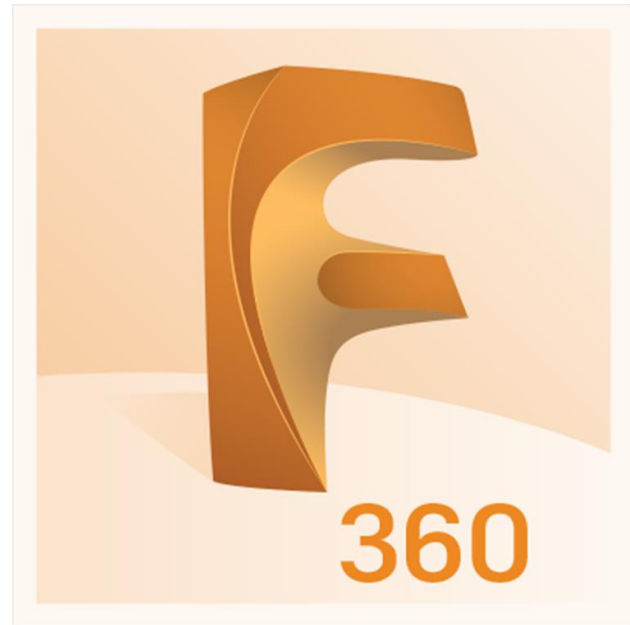


Validation in Fusion (again)

- Complete the Validation command one additional time after healing the model

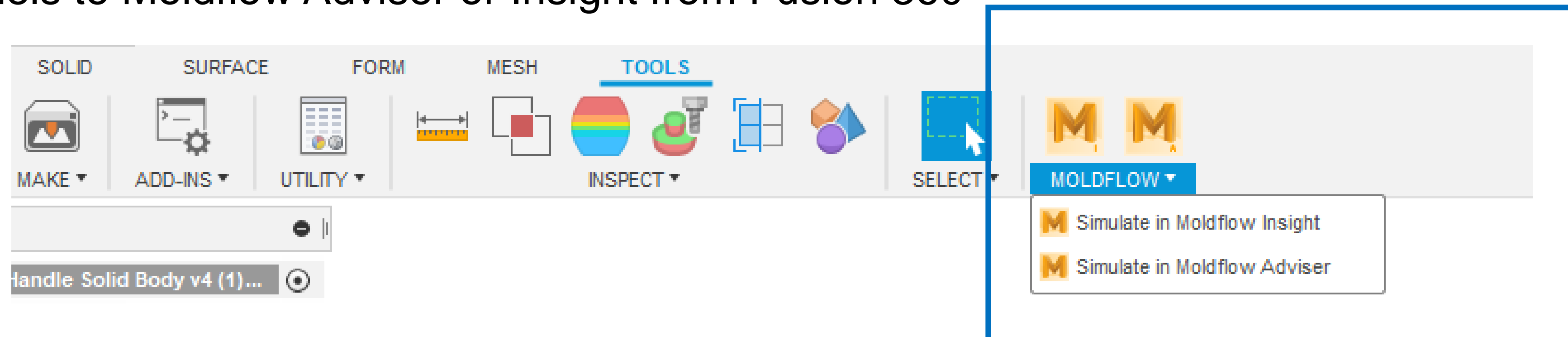


Fusion to Moldflow

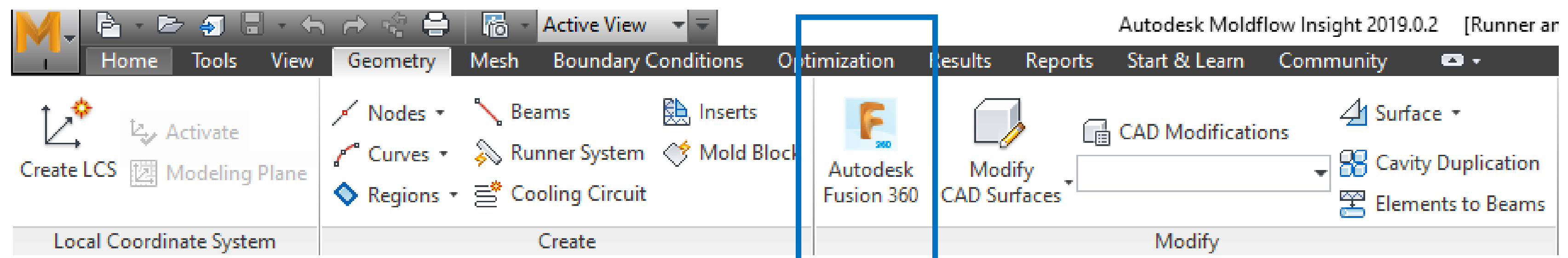


Connected Workflows Between Fusion & Moldflow

- Easily send models to Moldflow Adviser or Insight from Fusion 360



- Send models from Moldflow Insight back to Fusion 360



Autodesk Moldflow Injection Molding Software

- **Autodesk Moldflow Adviser**

- Part and Mold Design for Manufacturability
- Injection Molding Thermoplastics Only
- Ideal for Plastic Part Designers

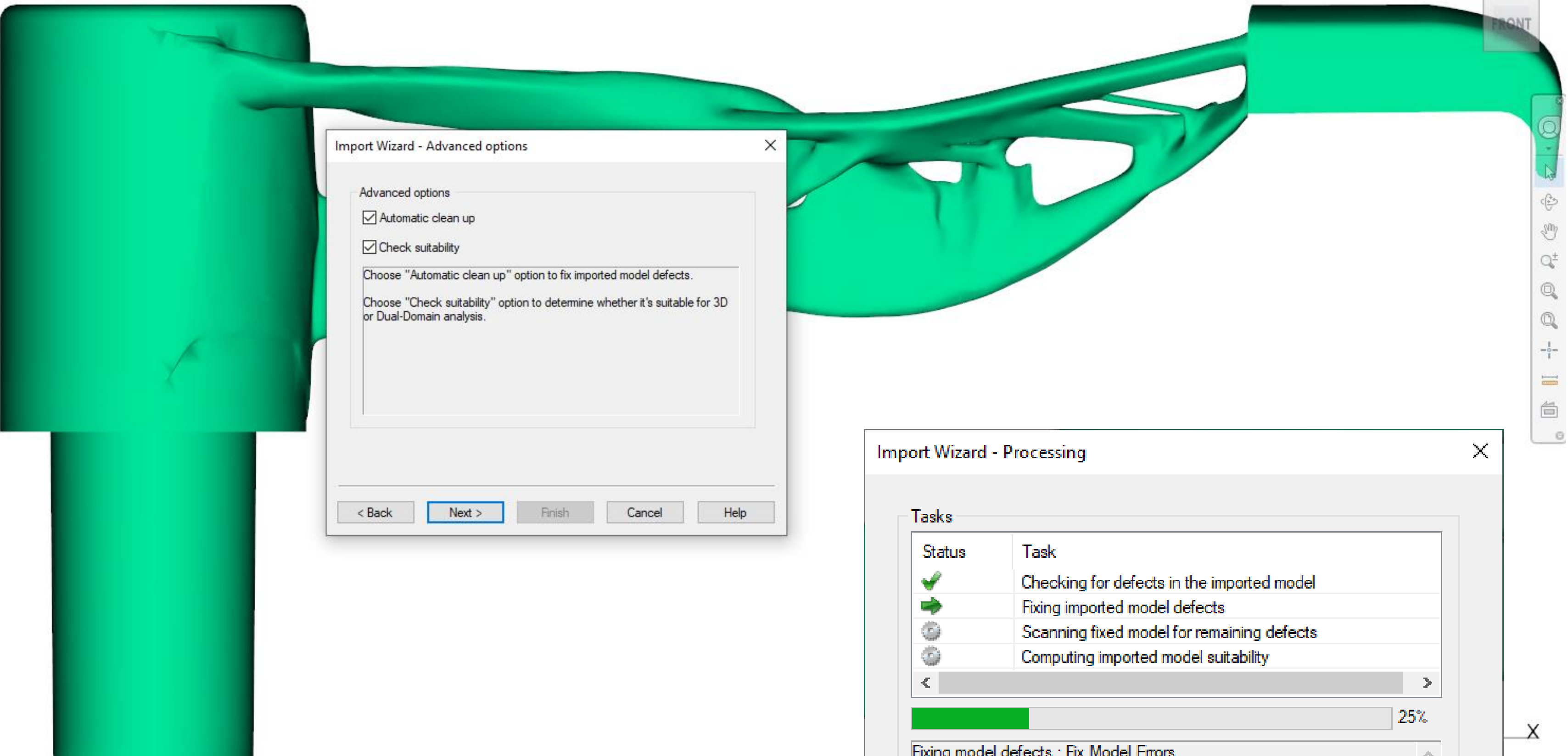


- **Autodesk Moldflow Insight**

- In-depth Part and Mold Optimization
- Thermoplastics, Thermosets, Powder Metal, & Ceramic materials
- Injection, Compression



Moldflow Adviser Import & Additional Model Checks



Import Wizard - Advanced options

Advanced options

☒ Automatic clean up

☒ Check suitability

Choose "Automatic clean up" option to fix imported model defects.

Choose "Check suitability" option to determine whether it's suitable for 3D or Dual-Domain analysis.

< Back Next > Finish Cancel Help

Import Wizard - Processing

Tasks

Status	Task
✓	Checking for defects in the imported model
➡	Fixing imported model defects
⌂	Scanning fixed model for remaining defects
⌂	Computing imported model suitability

< 25% >

Fixing model defects : Fix Model Errors

☒ Show Log

< Back Next > Finish Cancel Help

Import Wizard - Processing

Advice

The imported model is thin walled, and is recommended for Dual-Domain analysis.

Analysis type

☒ Standard - Dual Domain

☐ Advanced - True 3D

Dual-Domain is the standard analysis used by Autodesk Moldflow Adviser, it is recommended for thin wall models.

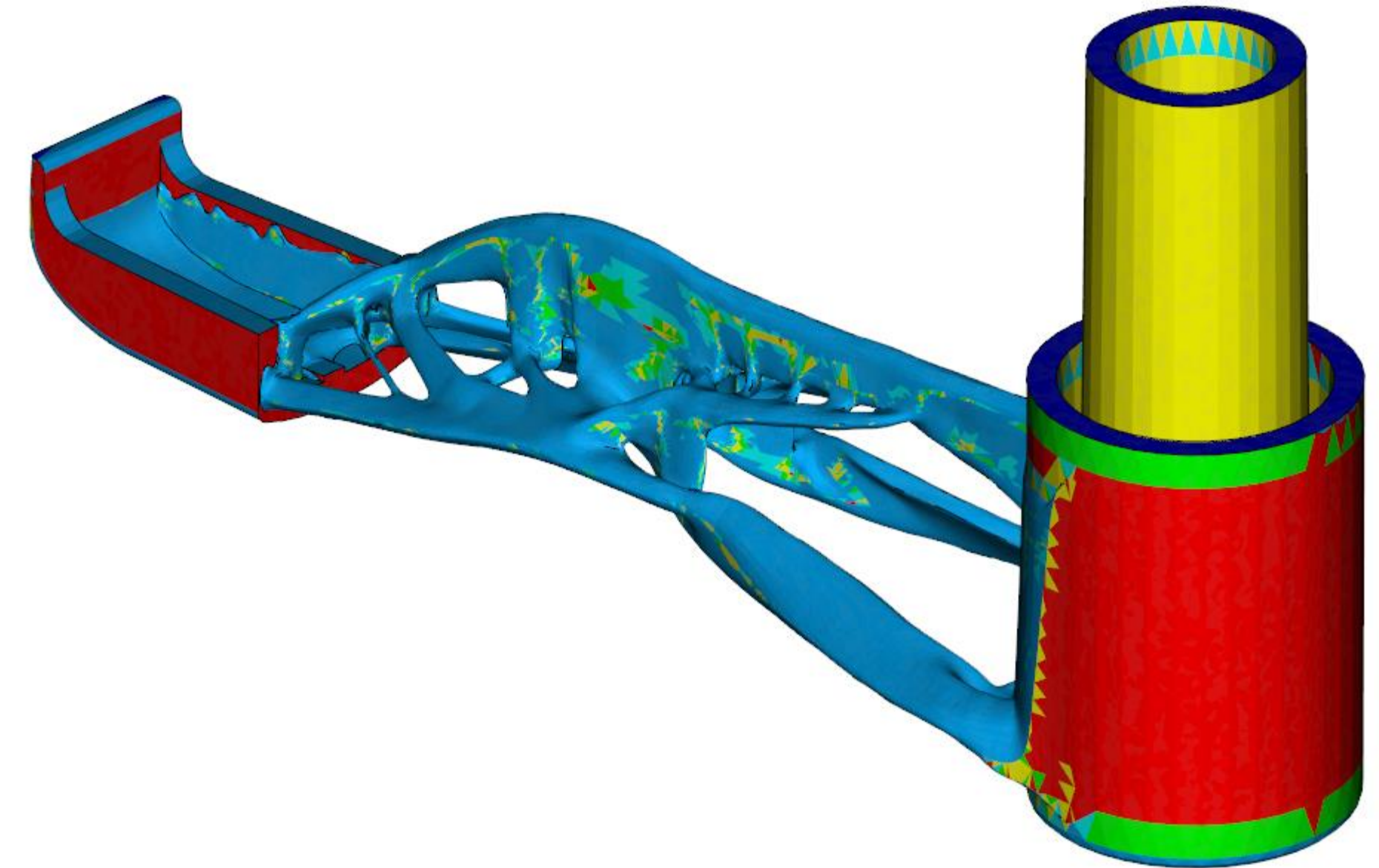
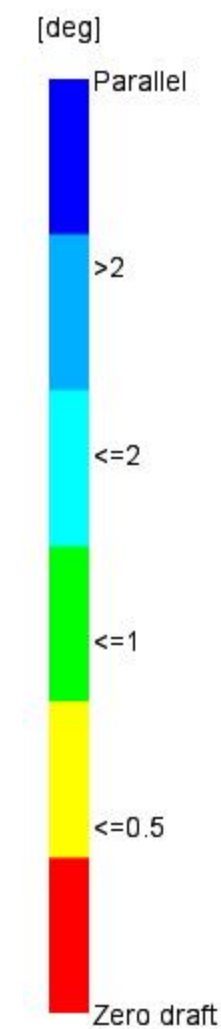
☐ Show Log

< Back Next > Finish Cancel Help

Design Adviser – Draft Angle

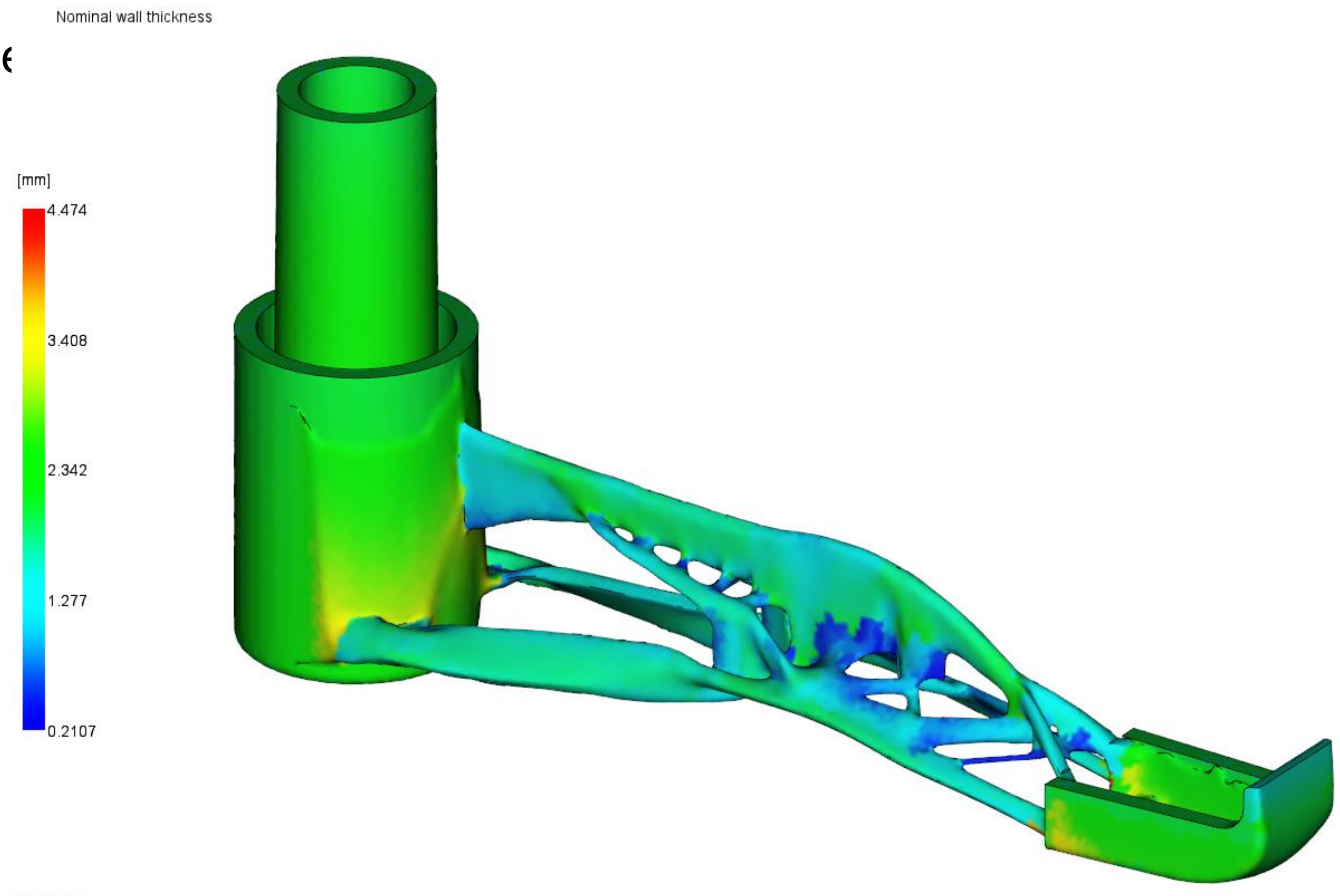
- The Draft Angle result displays draft variations
- As injection molded parts cool and shrink, they tend to shrink more on cores or male forms in the mold. This makes ejection difficult if draft is not included in the design
- Z+ Axis within Moldflow Adviser determines die draw or mold open vector

Draft angle



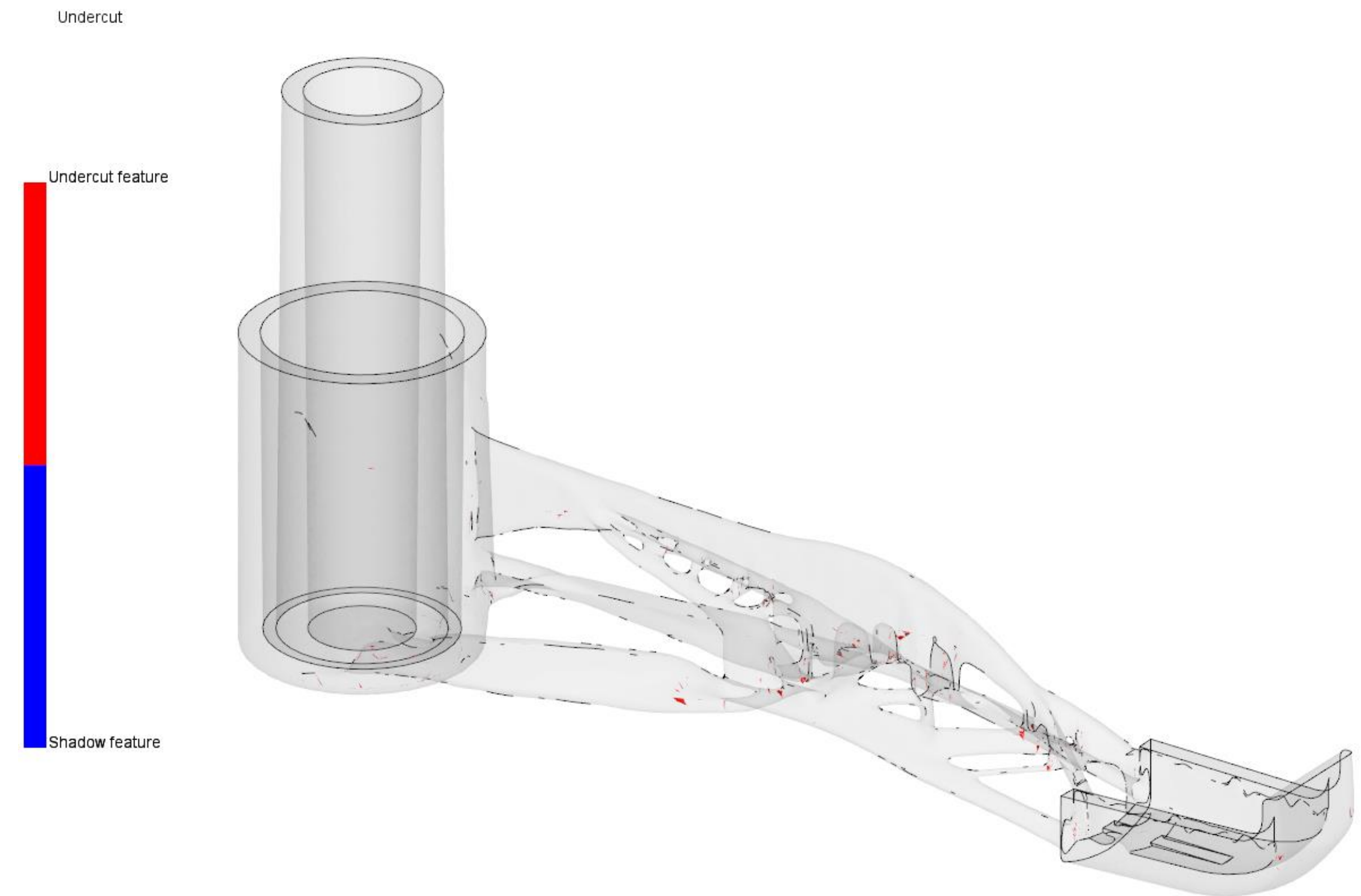
Design Adviser – Nominal Wall Thickness

- The Nominal wall thickness result displays thickness variations relative to the wall thickness of the part.



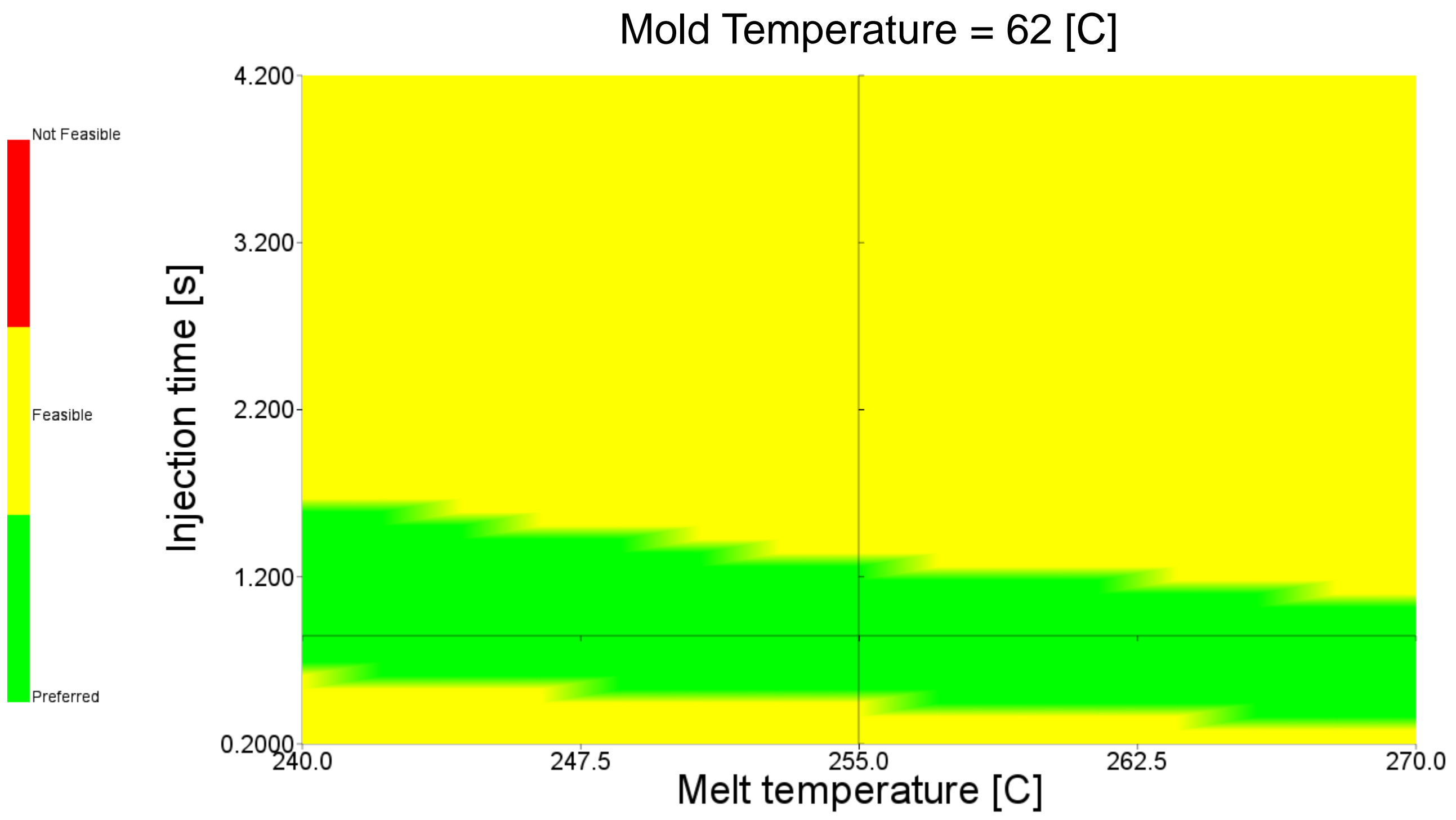
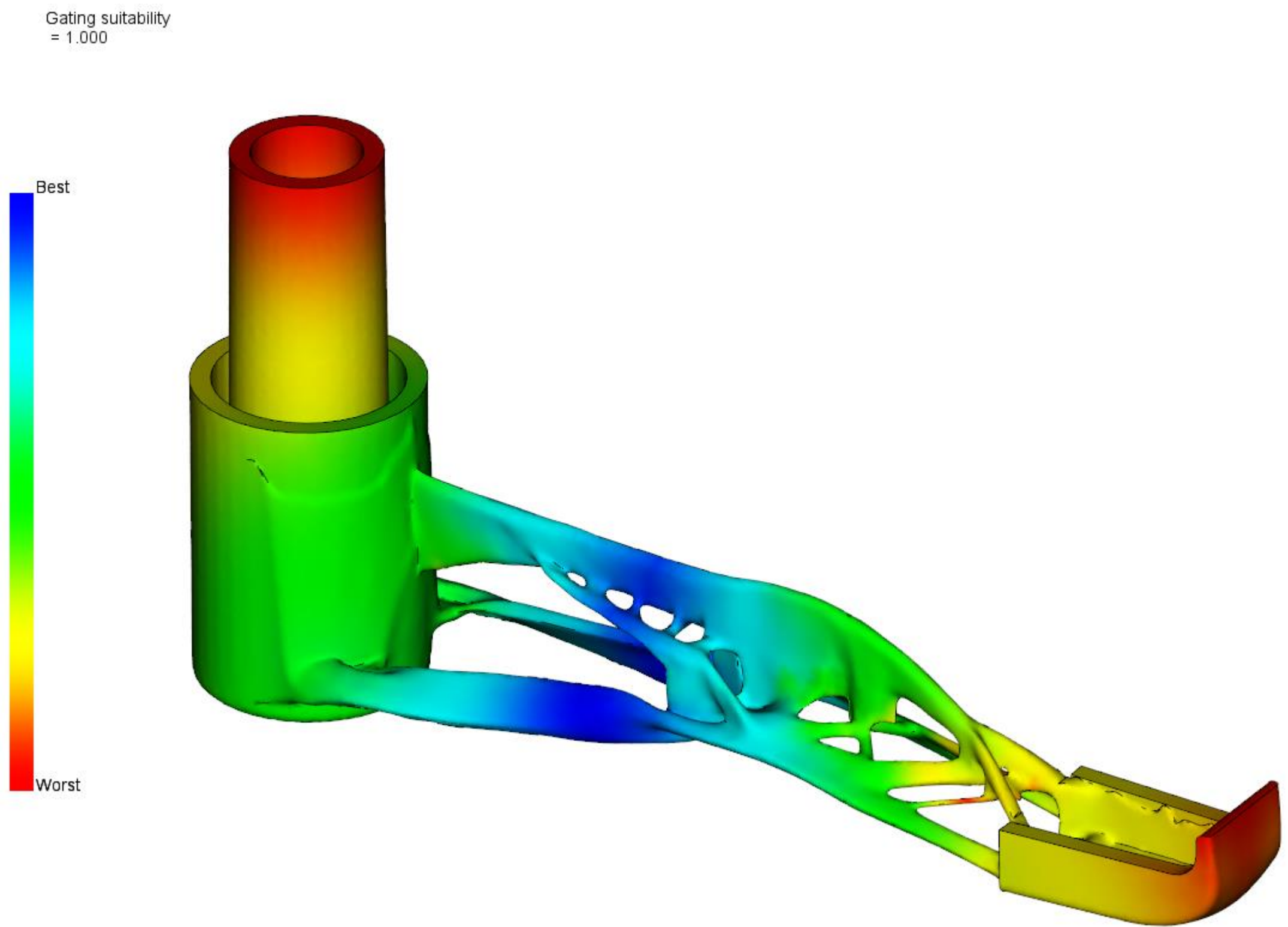
Design Adviser – Undercuts

- The Undercut result displays areas where undercuts are located.
- Undercuts are either mistakes in the model or features in the tool that require special tooling components such as sliders, lifters or collapsing cores, for the part to be ejected.



Additional Part Only Simulations

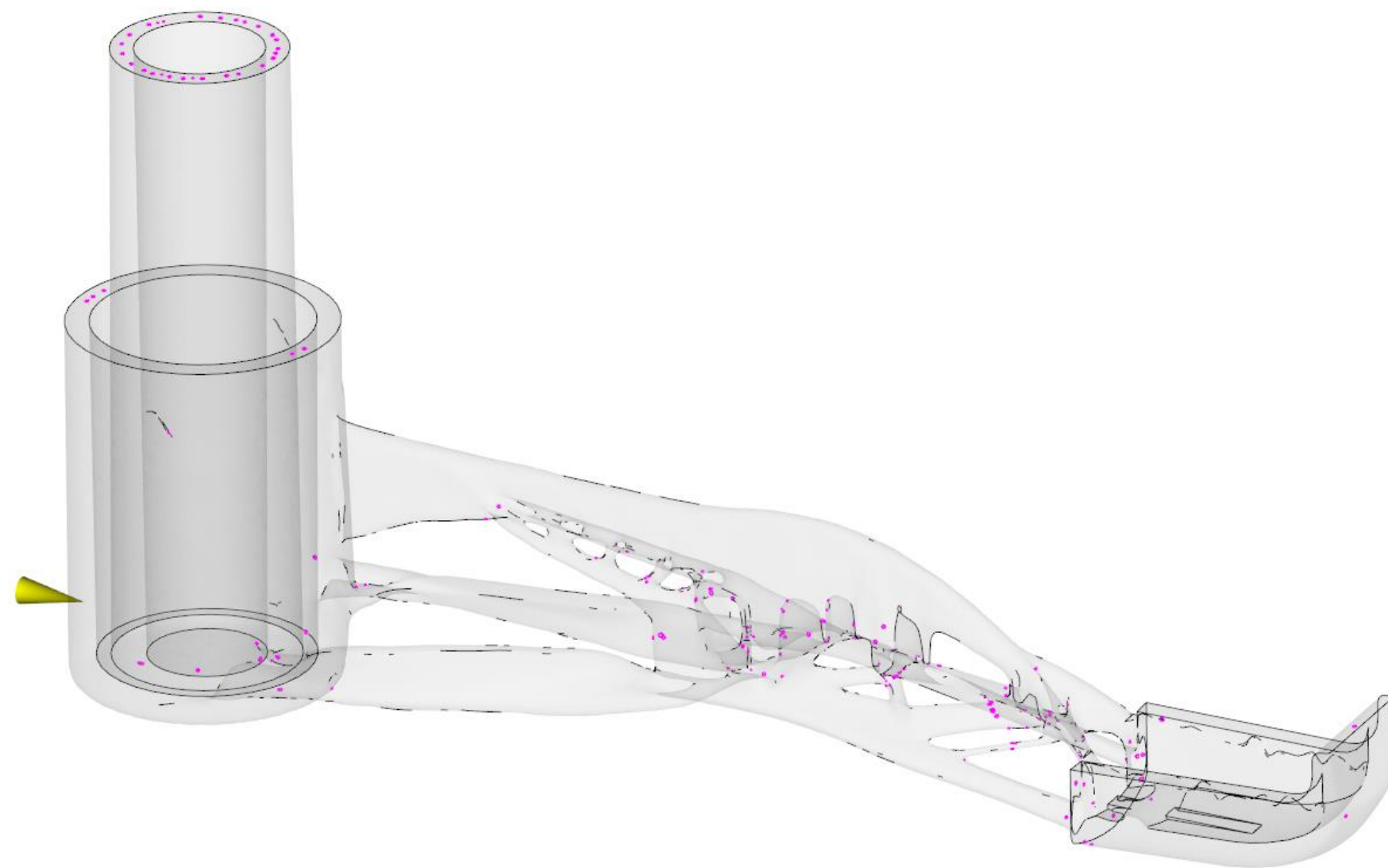
After initial design checks were made, additional simulations can be run to help determine ideal gating locations, material, and processing conditions



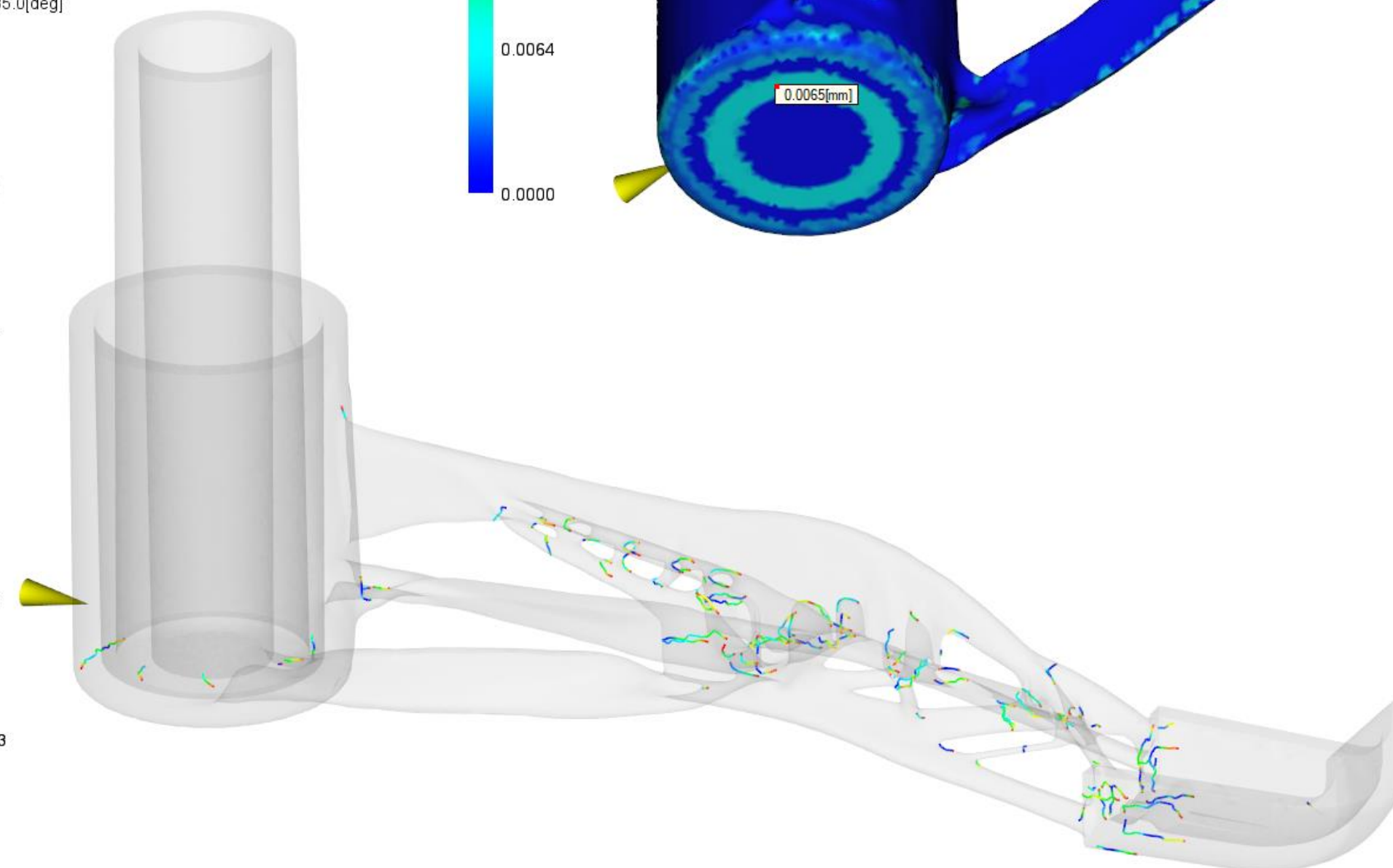
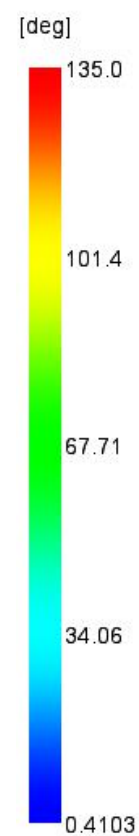
Additional Part Only Simulation Results

Potential part quality issues can be evaluated through Moldflow Adviser including Air Traps, Weld Lines and Sink Mark Estimates

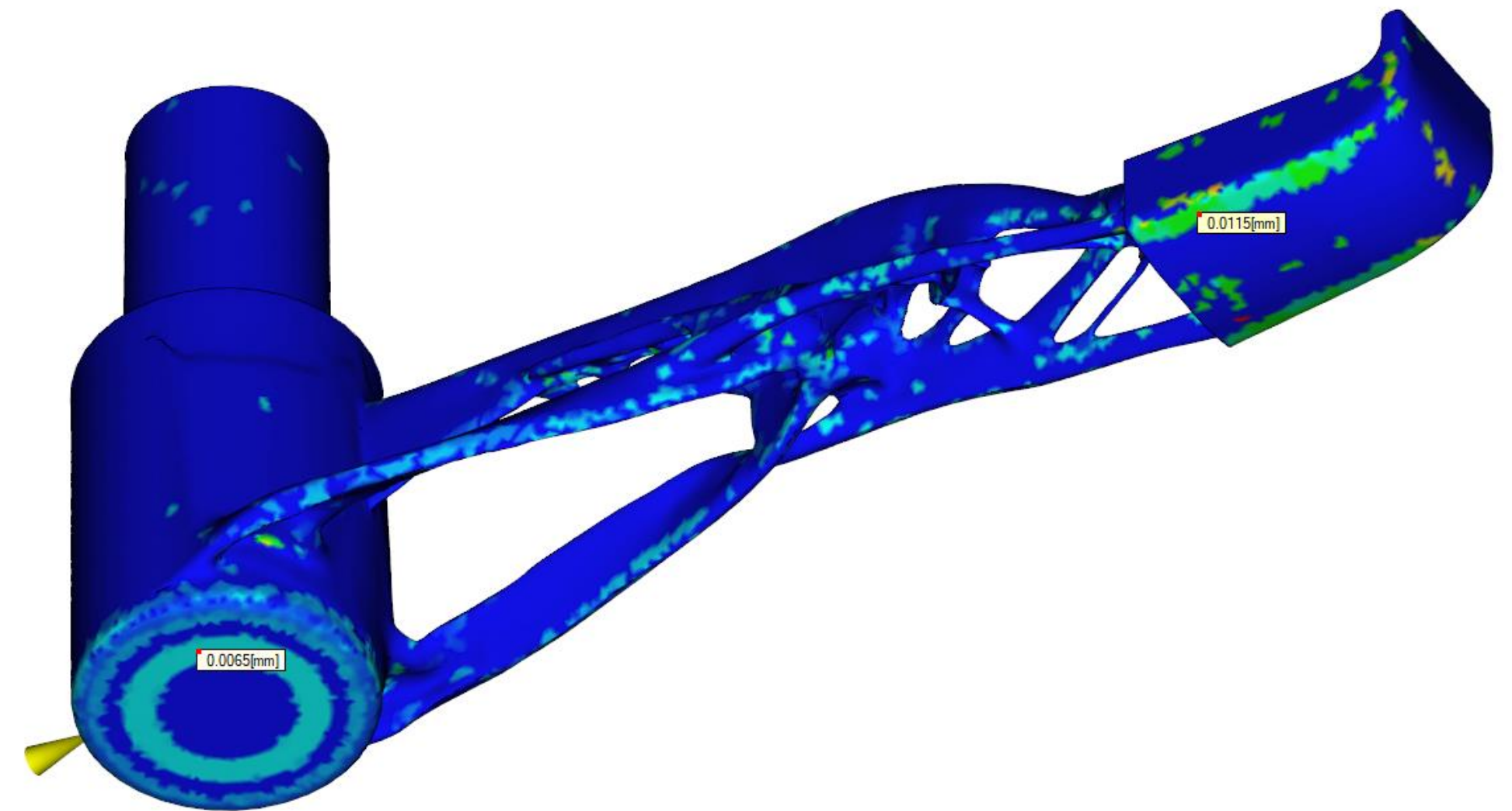
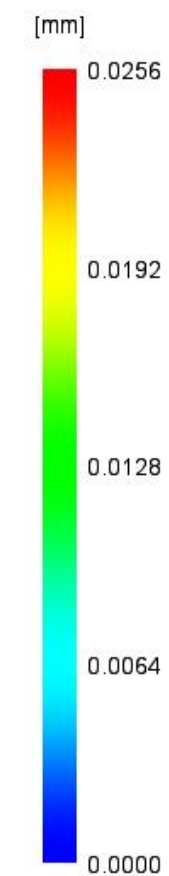
Air traps



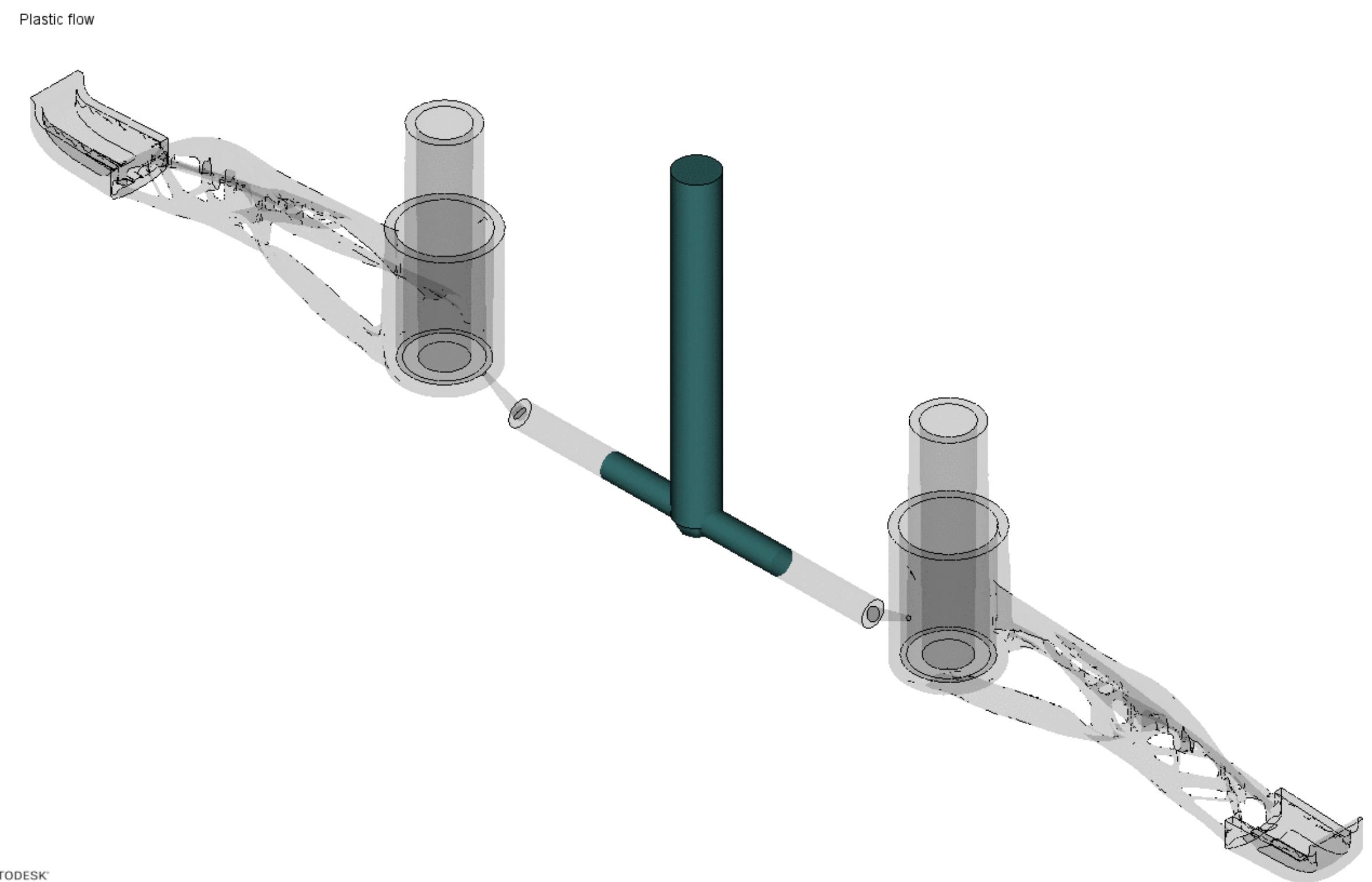
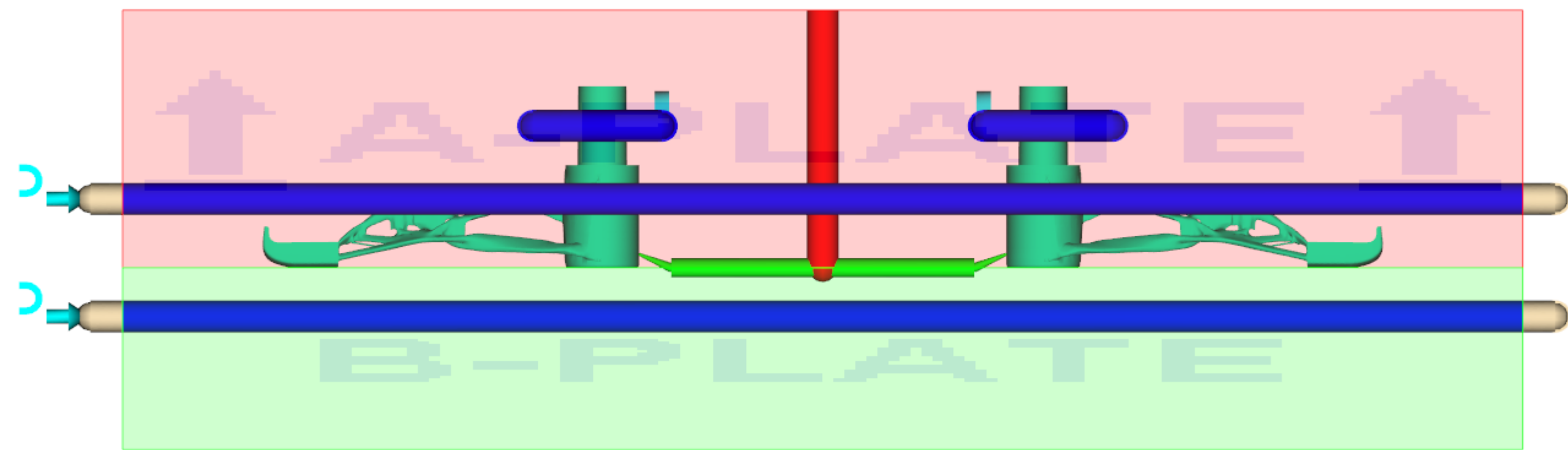
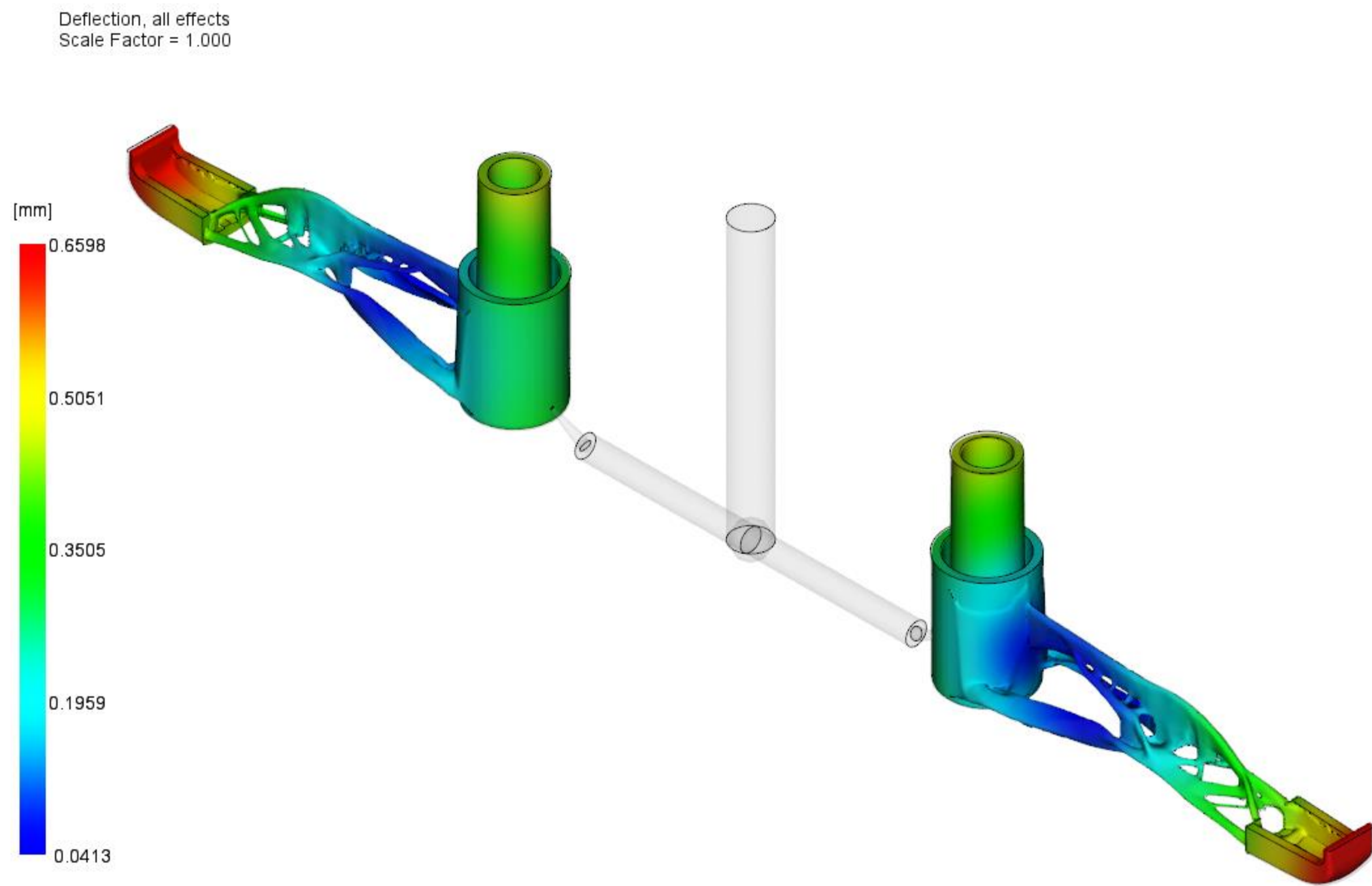
Weld lines
= 135.0[deg]



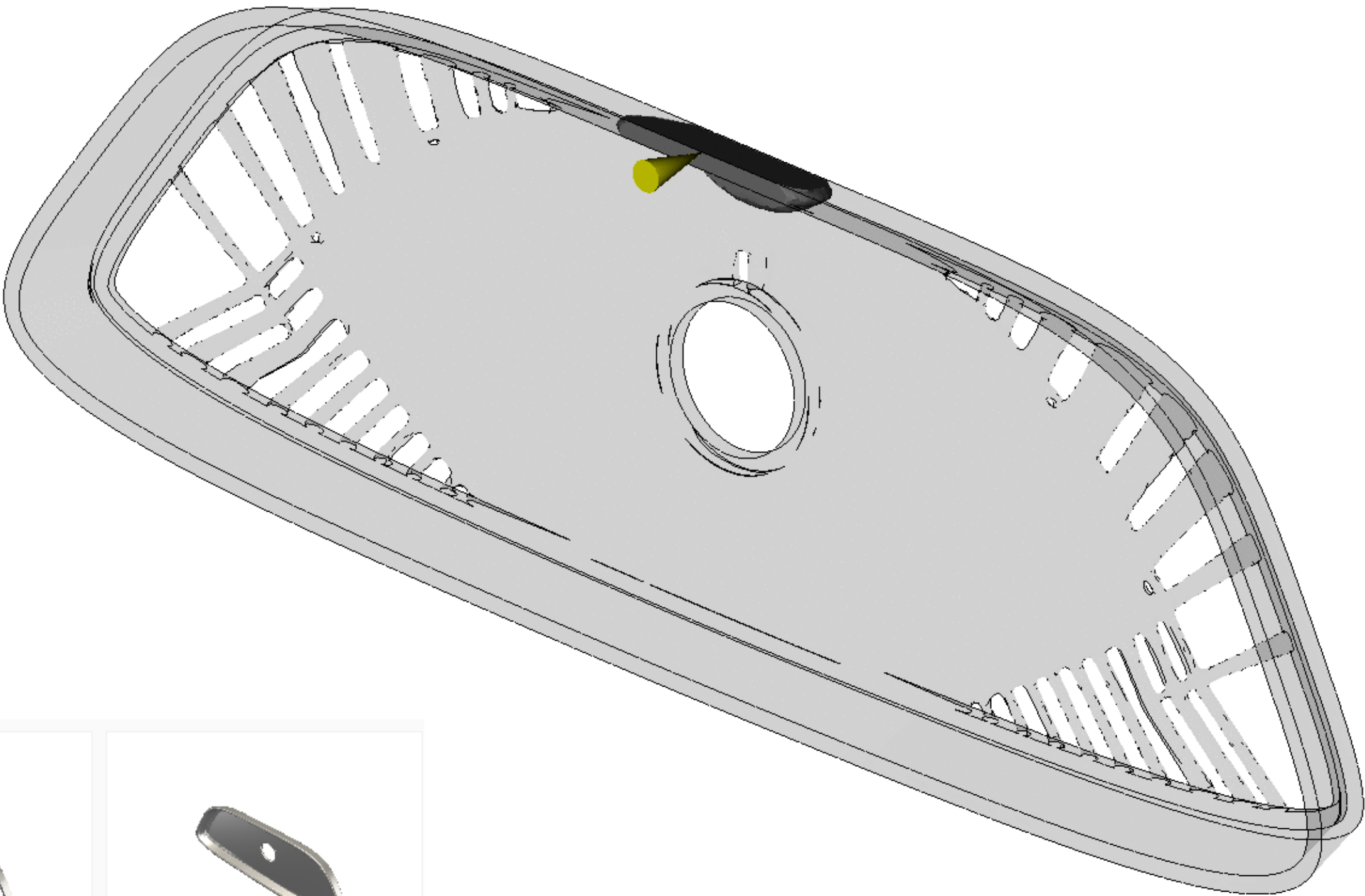
Sink marks estimate
Scale Factor = 1.000

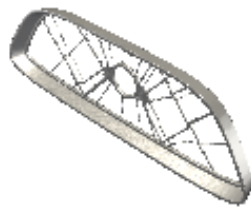
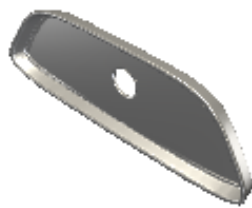

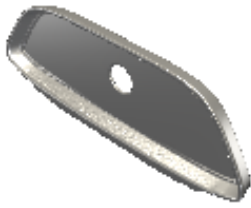
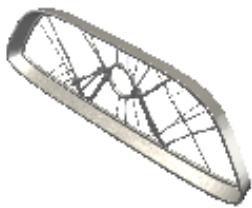
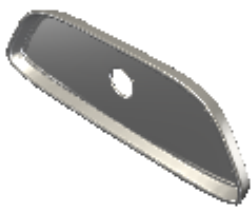
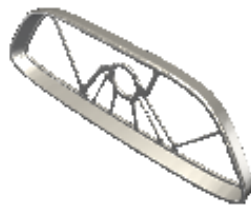
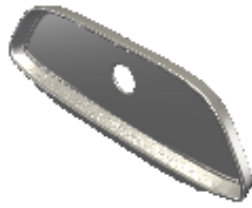

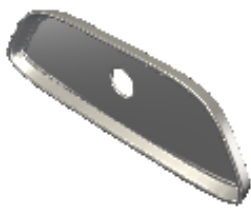


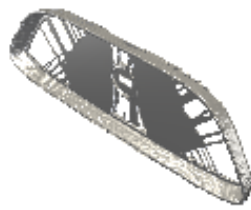


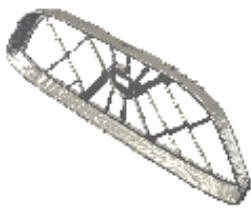
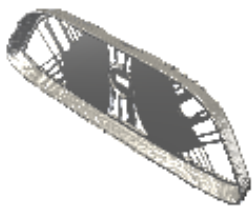



Cool+Fill+Pack+Warp Analysis

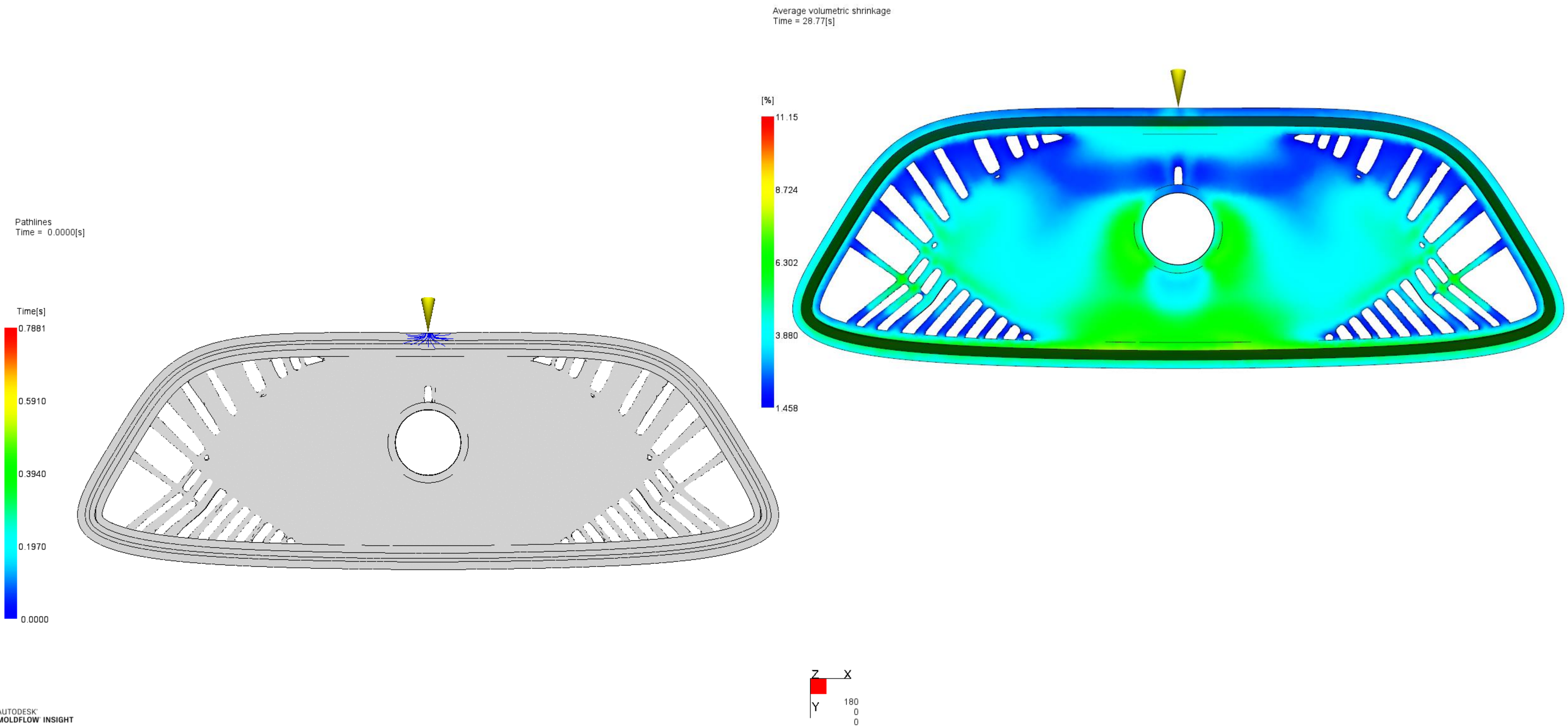


Generative Design for Plastic Housing

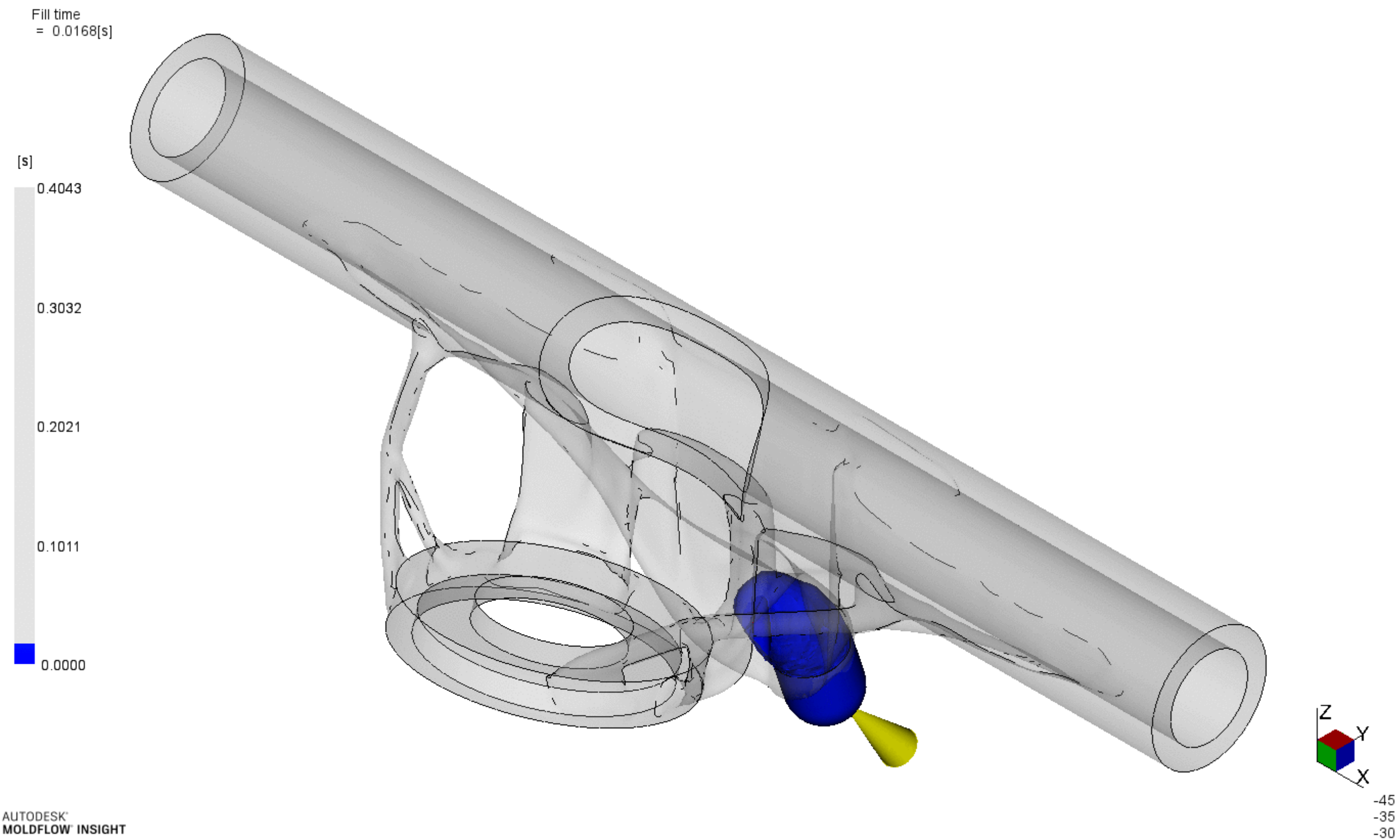
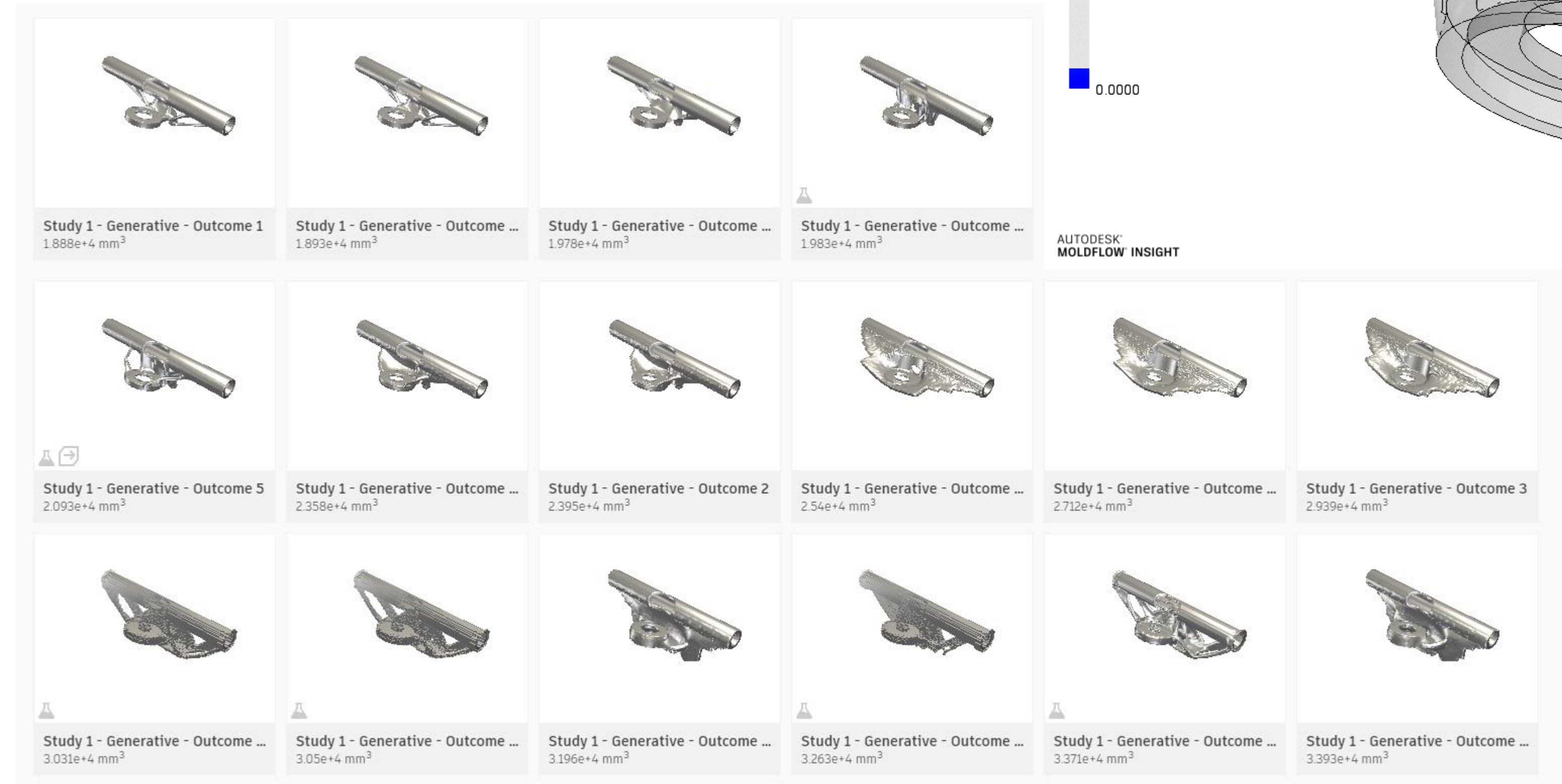


 <div>Study 1 - Generative - Outcome 1 Converged</div>	 <div>Study 1 - Generative - Outcome 2 Converged</div>	 <div>Study 1 - Generative - Outcome 3 Converged</div>	 <div>Study 1 - Generative - Outcome 4 Converged</div>	 <div>Study 1 - Generative - Outcome ... Converged</div>	 <div>Study 1 - Generative - Outcome ... Converged</div>
 <div>Study 1 - Generative - Outcome ... Converged</div>	 <div>Study 1 - Generative - Outcome ... Converged</div>	 <div>Study 1 - Generative - Outcome ... Converged</div>	 <div>Study 1 - Generative - Outcome ... Converged</div>	<div><input type="checkbox"/></div>  <div>Study 1 - Generative - Outcome ... Converged</div>	 <div>Study 1 - Generative - Outcome ... Converged</div>
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Moldflow Insight – Thermoplastic Results



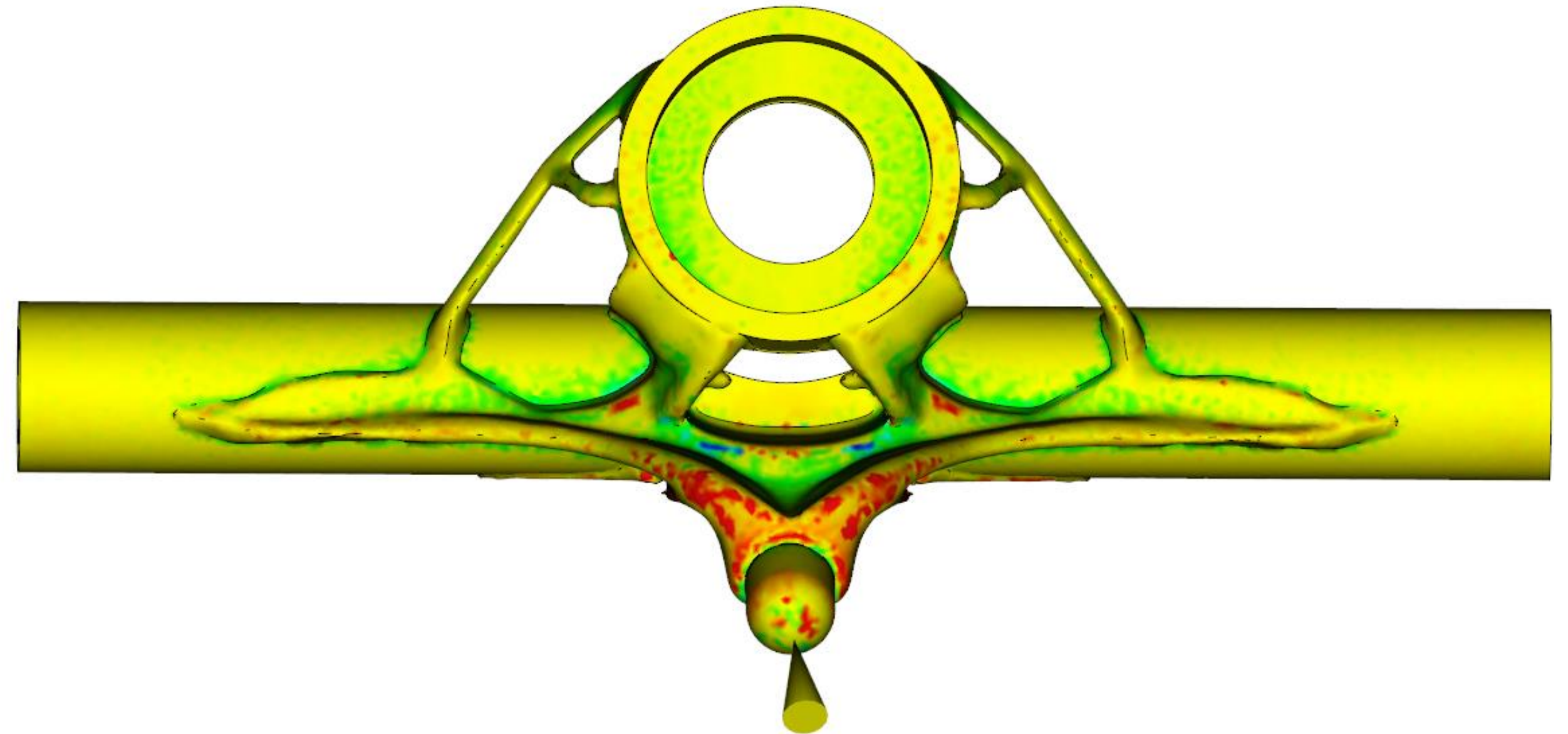
Generative Design for Powdered Metal Injection Molding



Moldflow Insight – Powder Metal Results

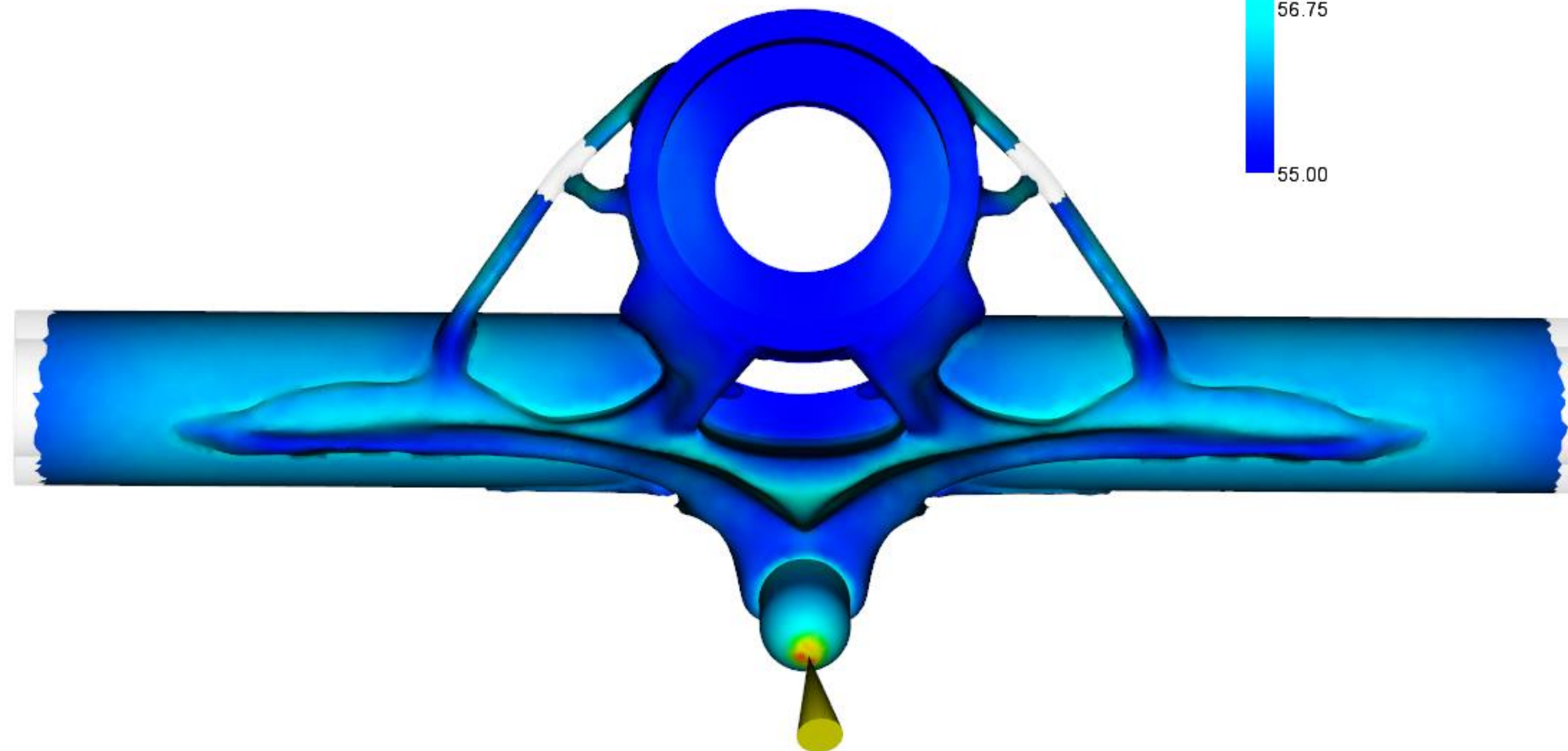
Powder volume concentration
Time = 30.39[s]

[%]
62.00
60.25
58.50
56.75
55.00



Shear stress at wall
Time = 0.3946[s]

[MPa]
1.116
0.8372
0.5581
0.2791
0.0000



Call to Action

DOWNLOAD THE FREE TRIAL!

Non-commercial, Commercial and Educational Use trials
available based on customer needs

Trial version of Moldflow Adviser also available

USE THE FREE CLOUD CREDITS

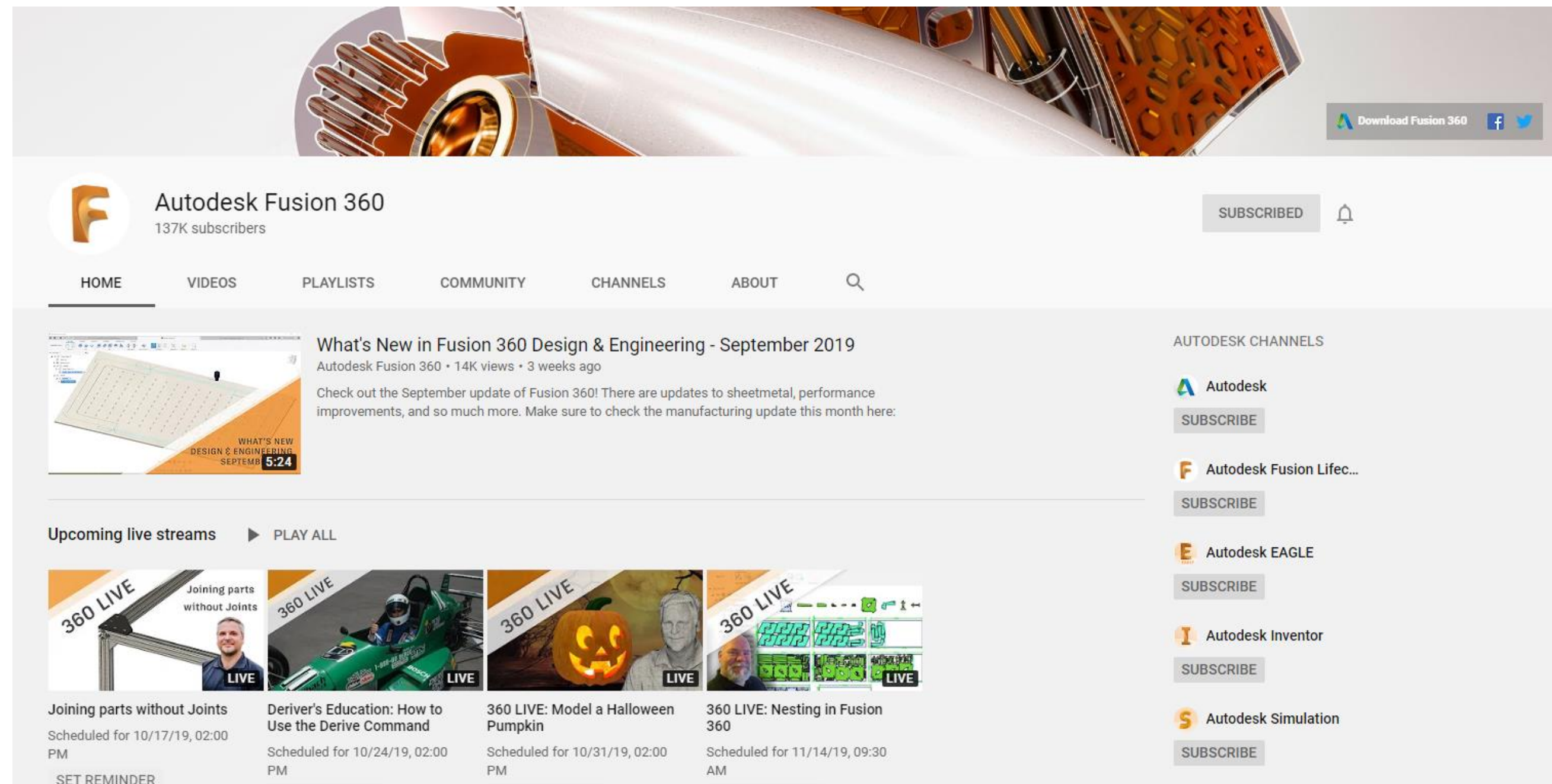
100 Cloud Credits Free with Trial Version

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[Autodesk Fusion 360 – YouTube](#)

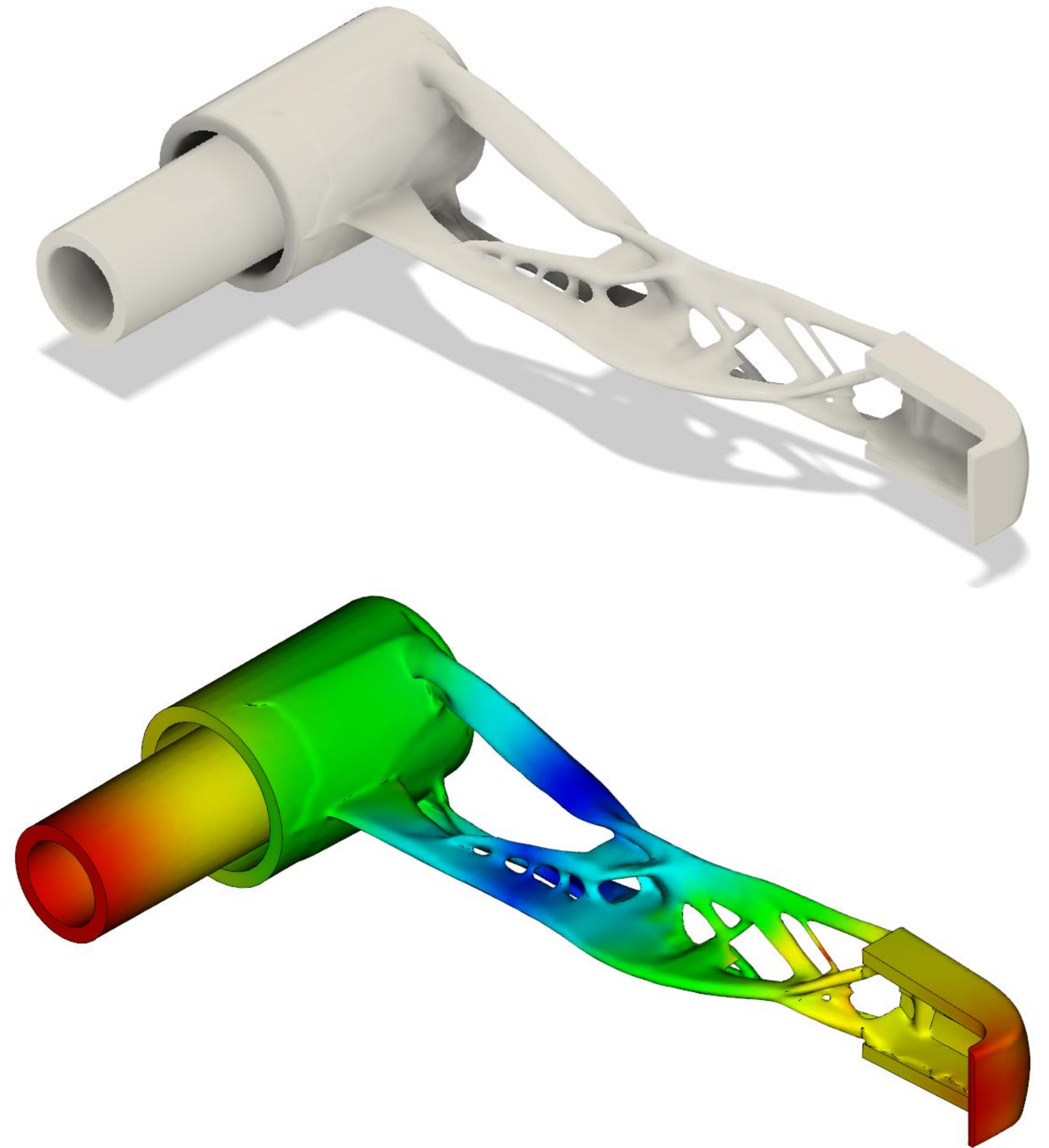
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Summary

Generative Design within Fusion 360 is a powerful design tool that allows part designers the freedom to explore new, innovative design concepts. Using additional simulation tools allows designers and engineers the ability to validate these new design concepts.





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