Leveraging Generative Design Technology to Enhance Product Design for Manufacturing

Adam James & Mason Myers

Product Specialist and Sr Implementation Consultant

AUTODESK. UNIVERSITY

About Adam

Technical Specialist, Moldflow

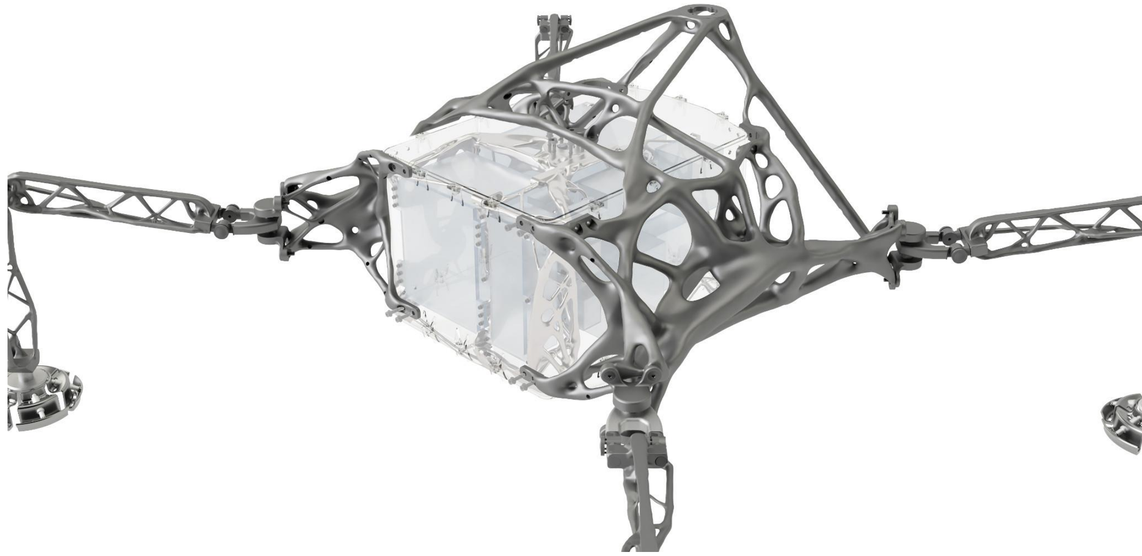
Adam studied Plastics and Composites Engineering at Western Washington University and has gained exposure to a variety of Autodesk products including Moldflow, Fusion 360, and Netfabb. His experience revolves around product design for mass manufacturing, additive manufacturing, and injection molding 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.

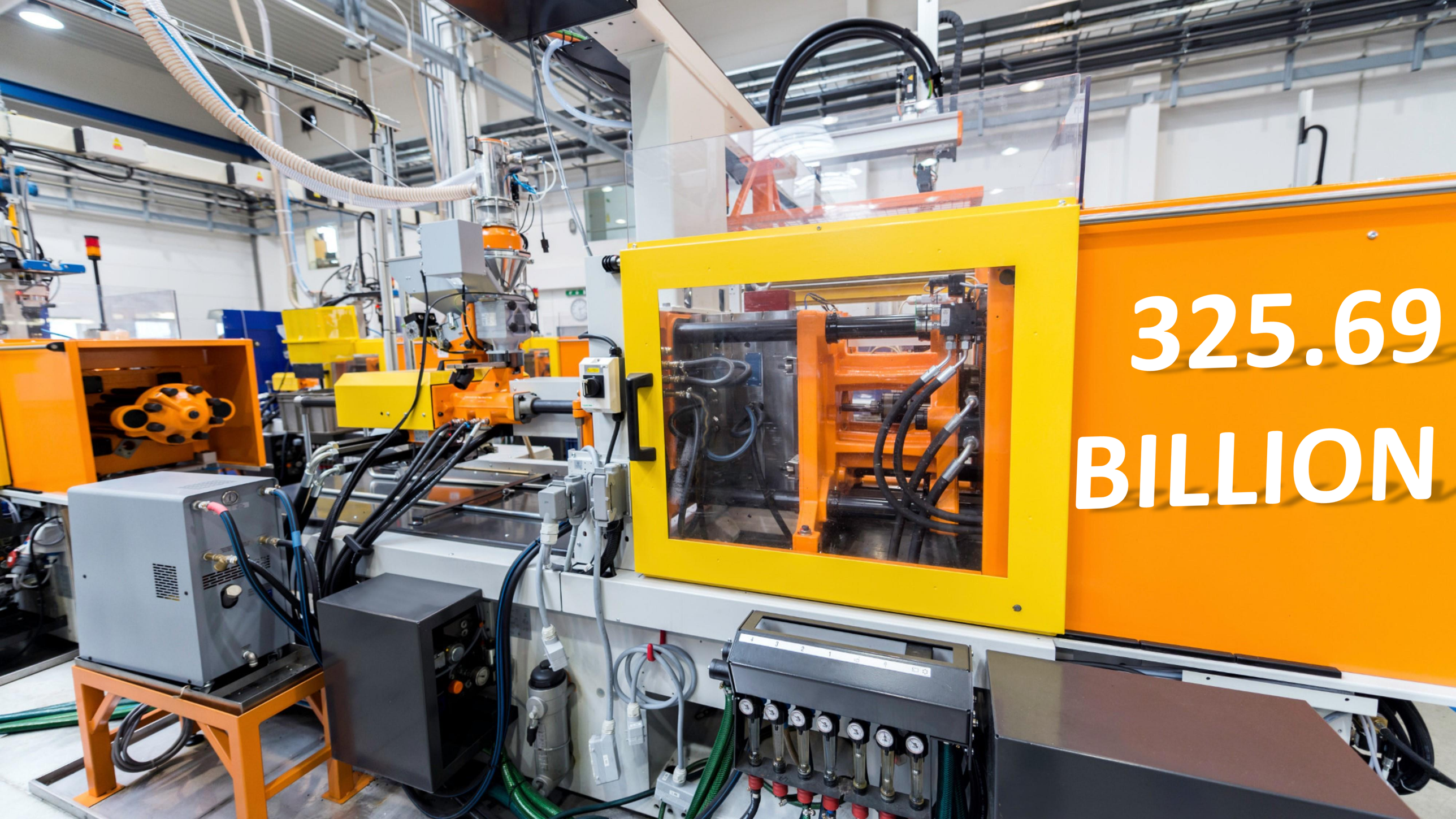
Benefits of Generative Design



- 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?


325.69
BILLION


MORE IS INEVITABLE

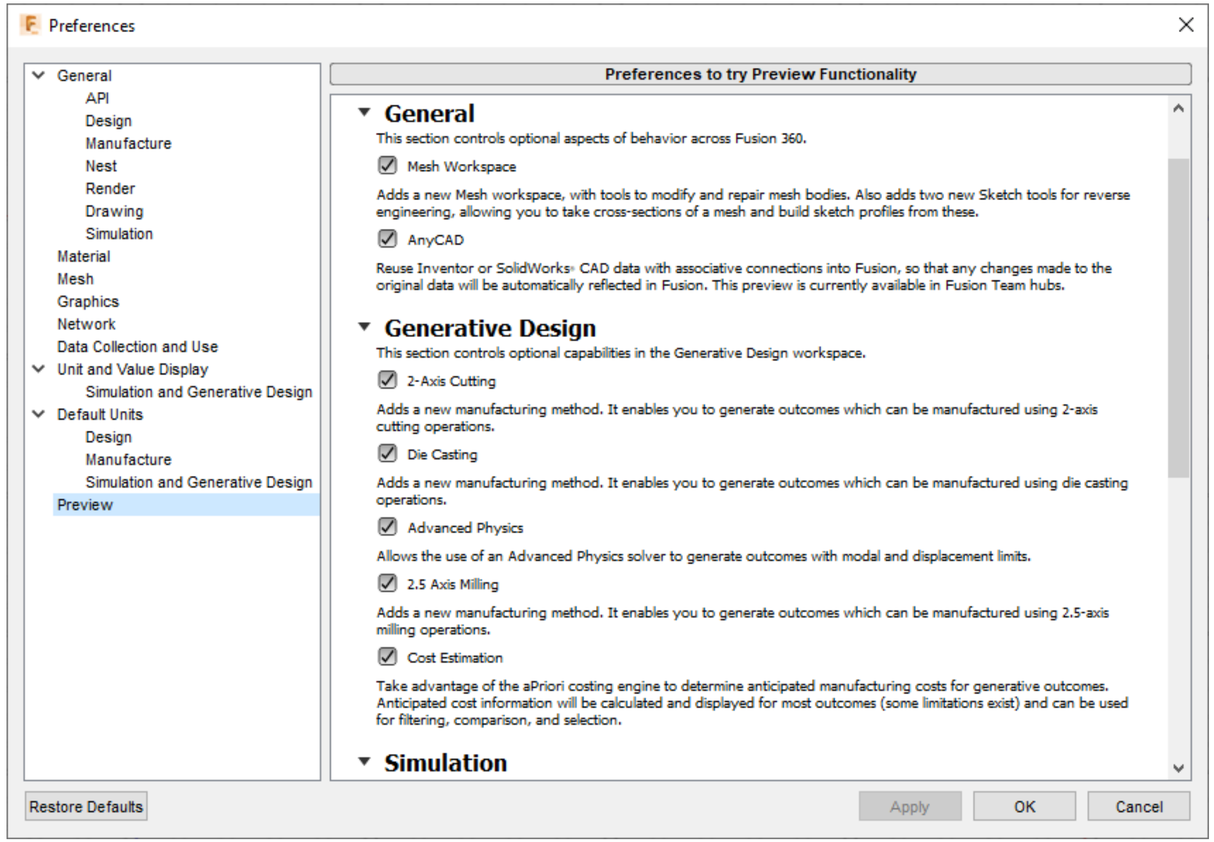

GENERATIVE = LESS

Additive has taken the spotlight

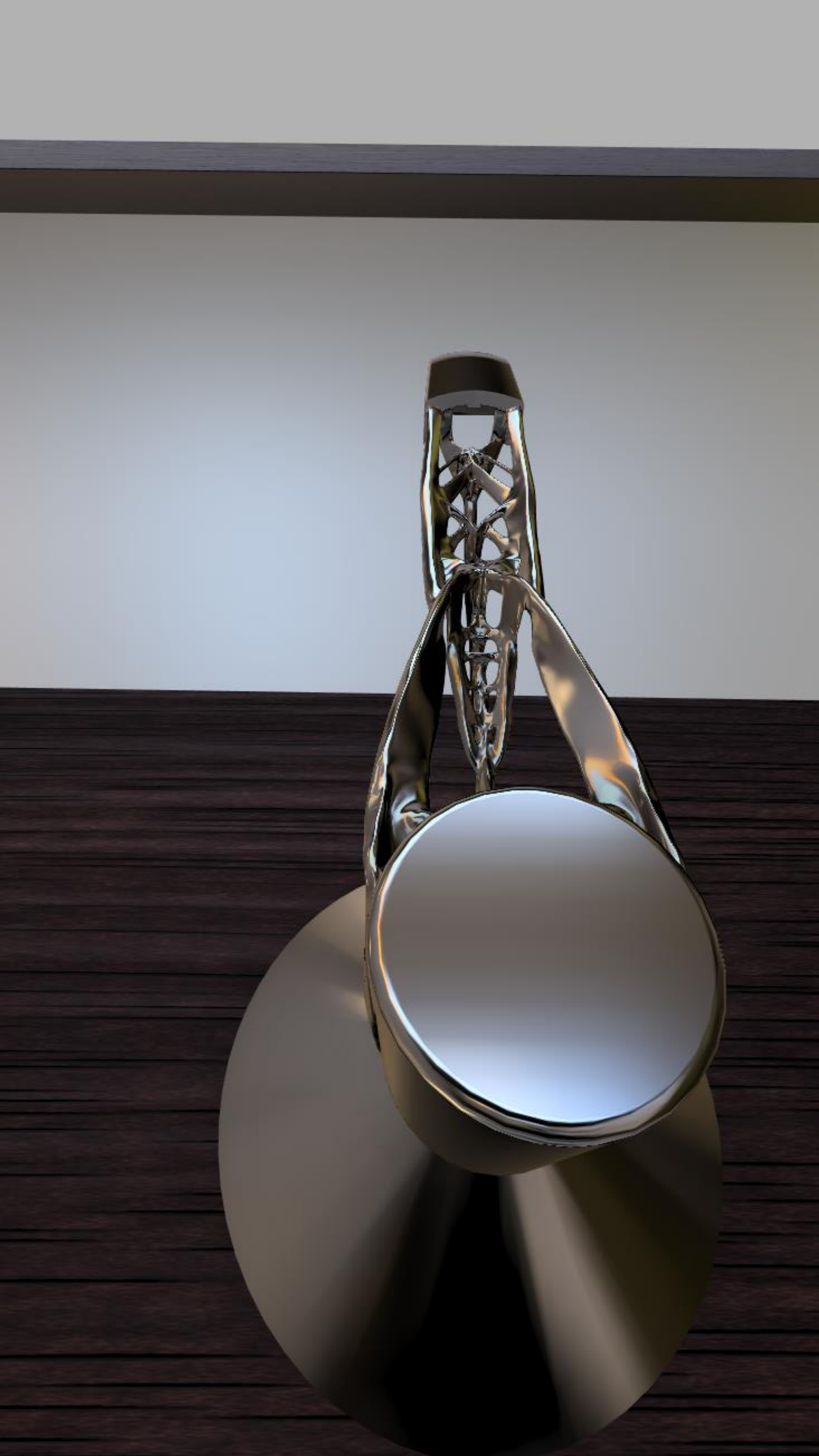
- New features allow incorporation of mass manufacturing constraints
- Additive is great for one off products
- Die Casting and Injection Molding lead the industry in high volume products

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

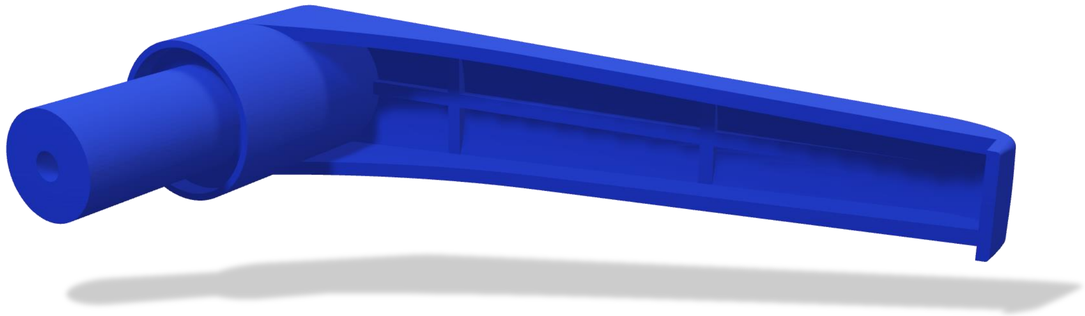


Figure 1: Original 3D model

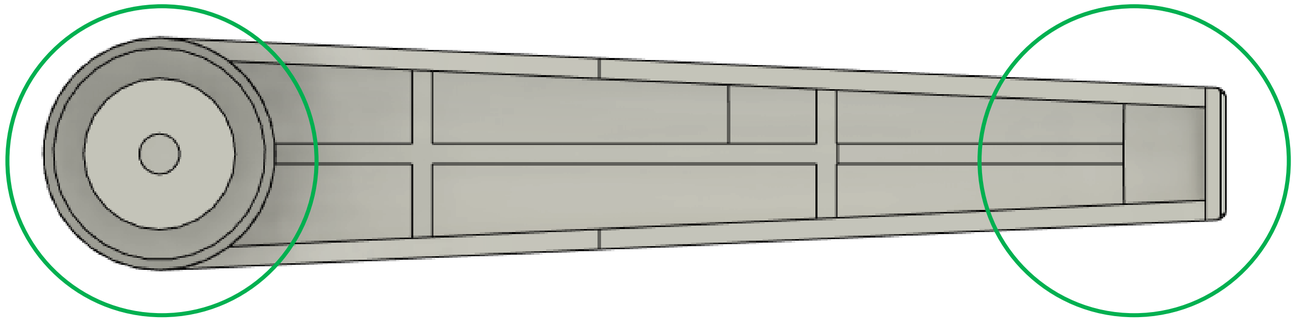


Figure 2: Areas of preserve geometry

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

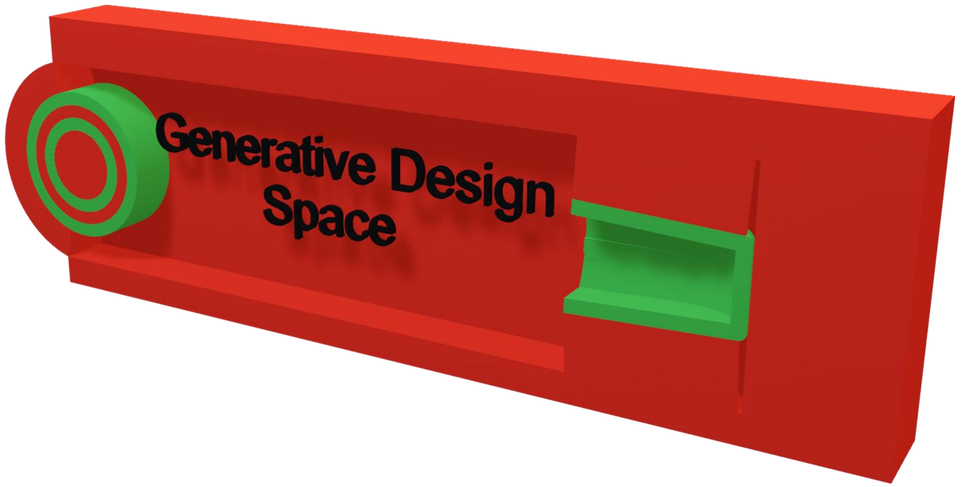


Figure 5: Obstacle Geometry Section View

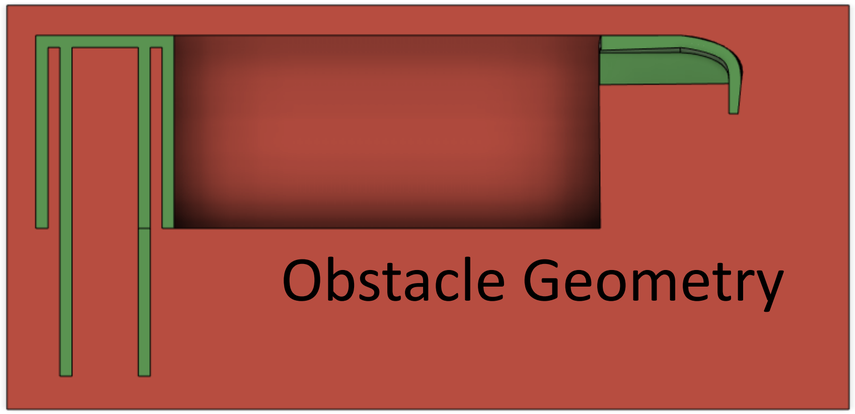


Figure 6: Obstacle Geometry Top Down

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

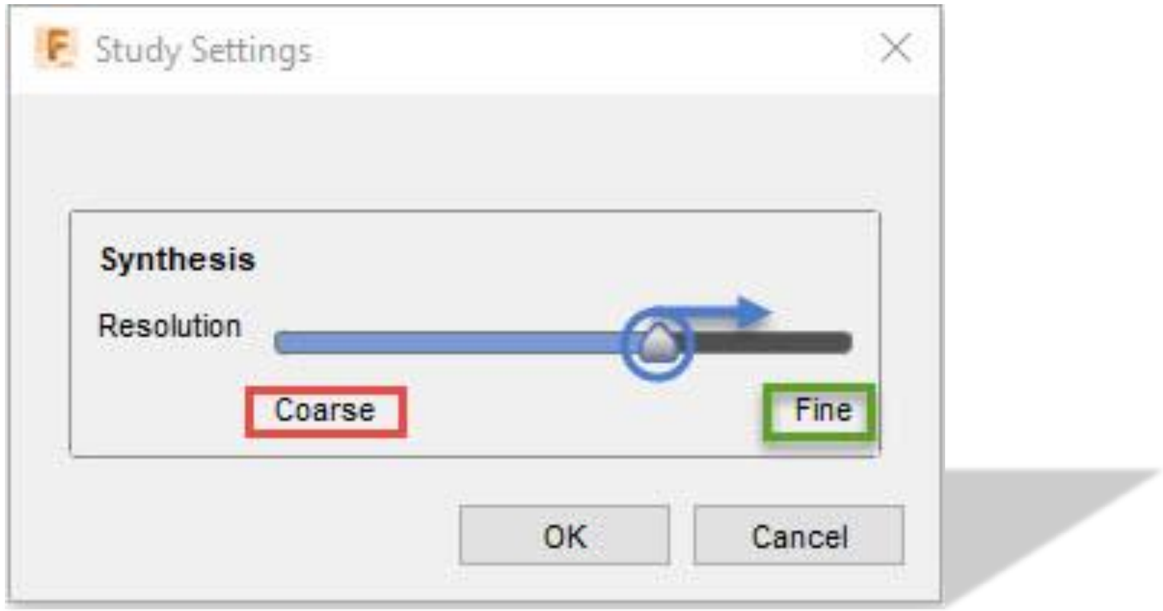
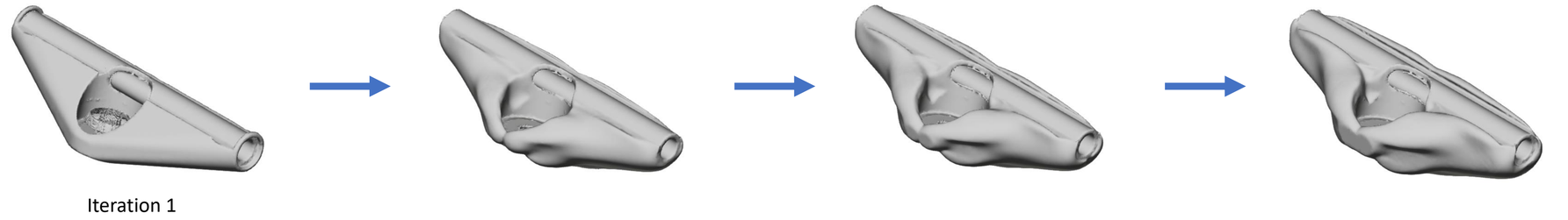
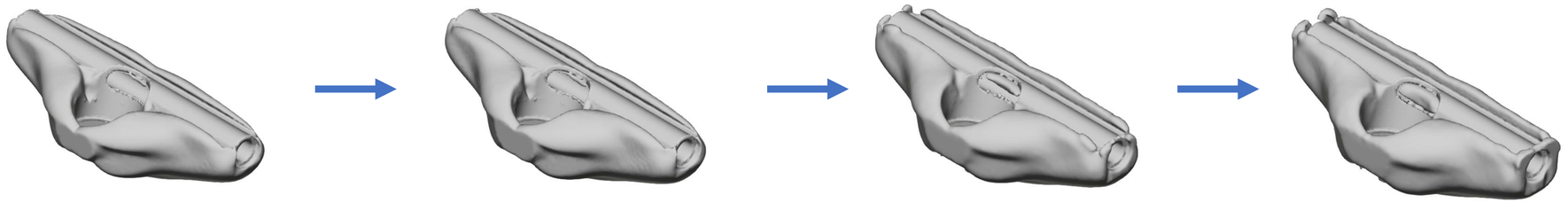


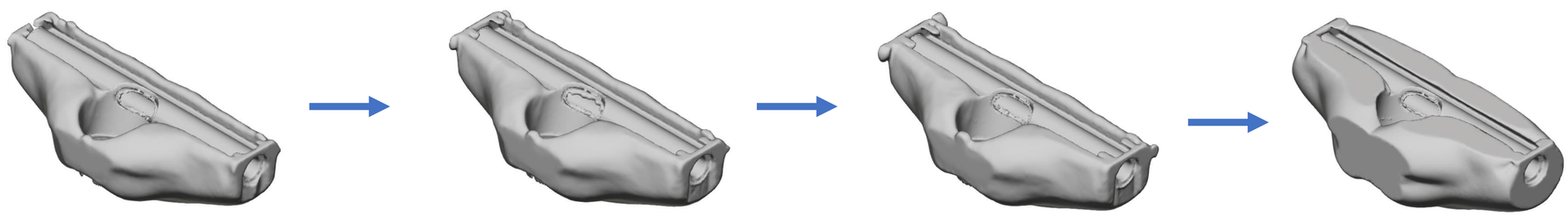
Figure 7: Synthesis Resolution Scale

Why is Synthesis Resolution Important?



Iteration 1





Iteration 23

Do we need say more?

Figure 8: Coarse Resolution

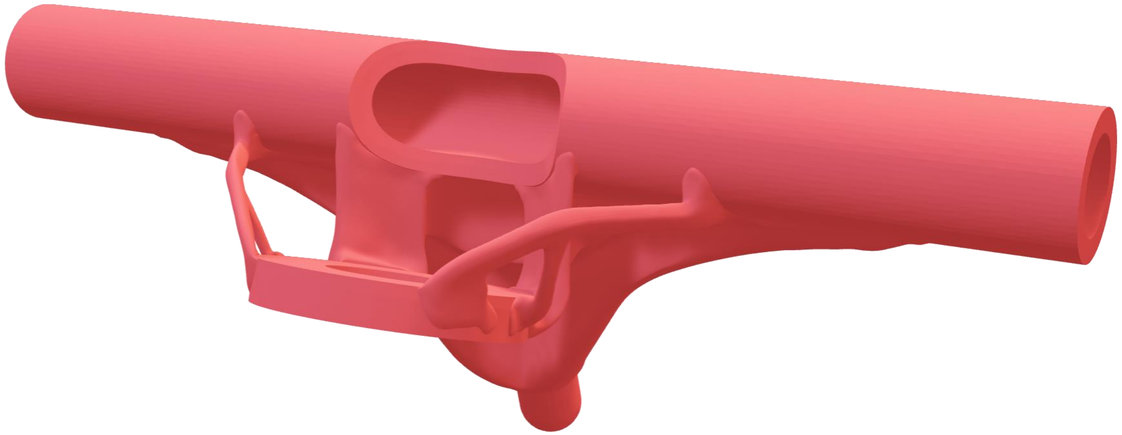
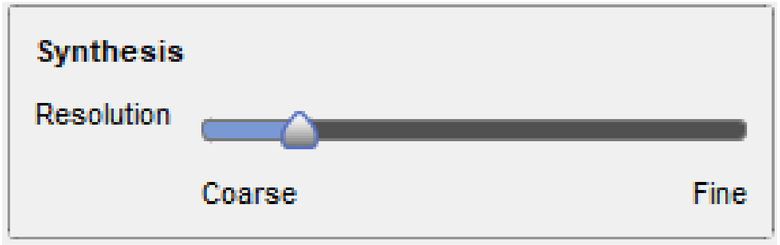
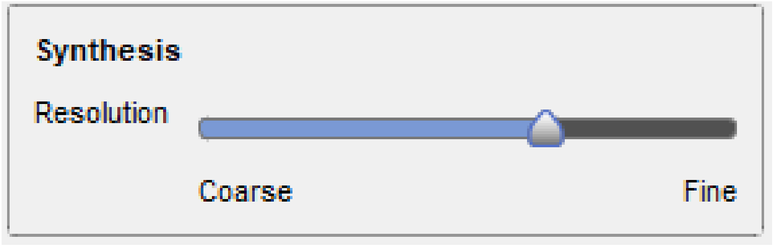


Figure 9: Fine Resolution





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

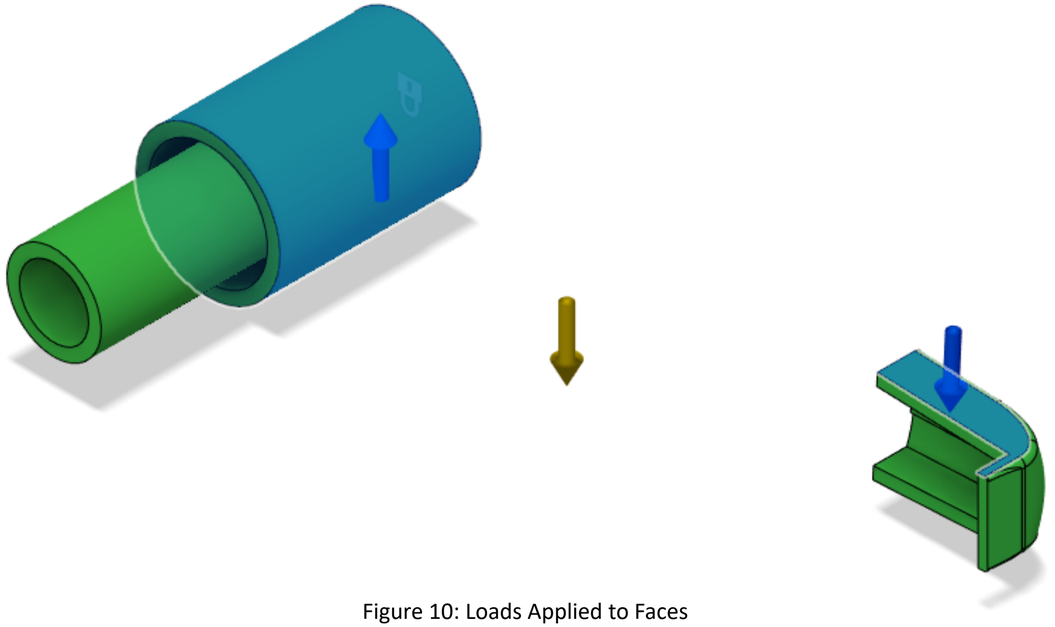


Figure 10: Loads Applied to Faces

Manufacturing

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

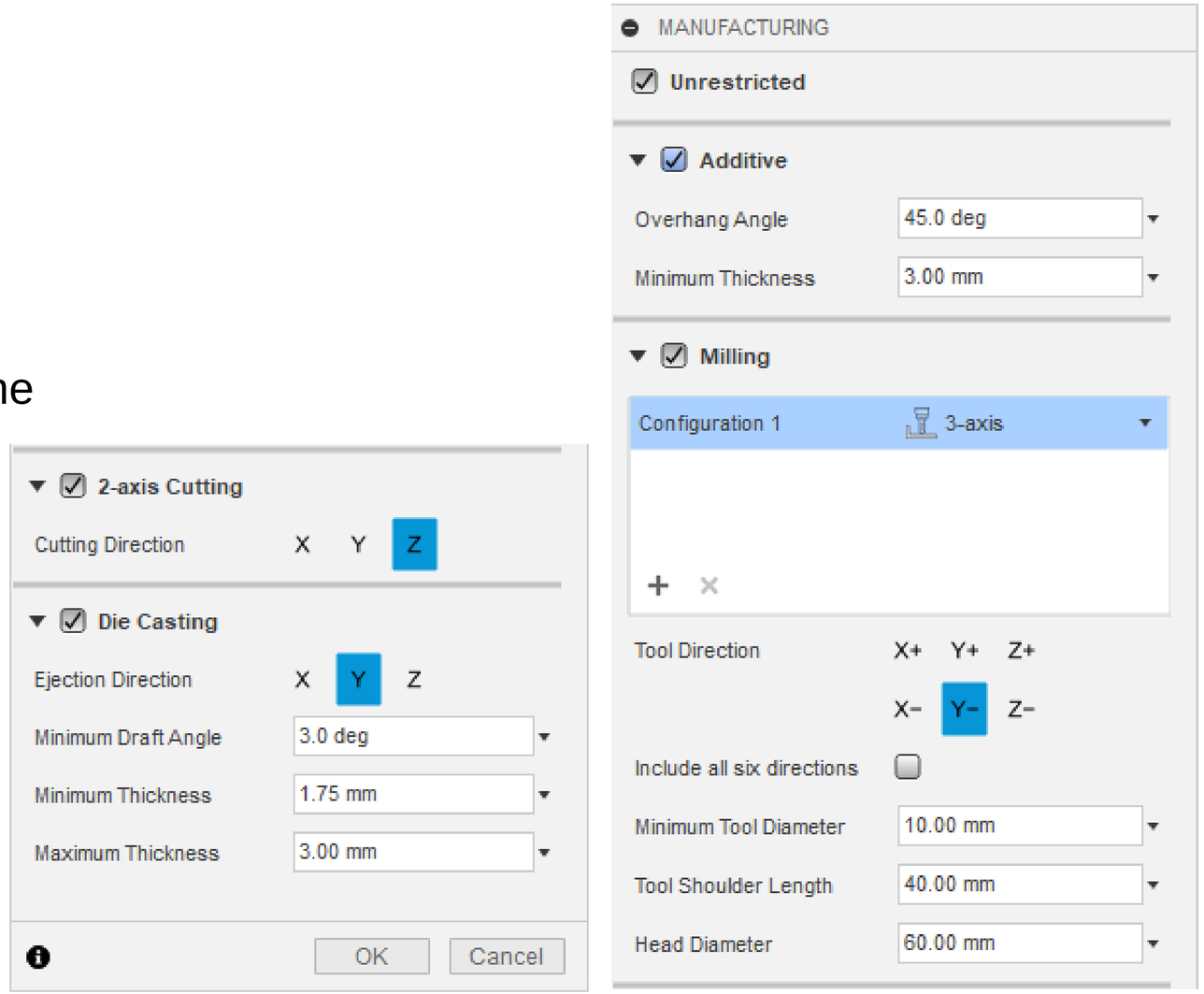


Figure 11: Manufacturing Settings

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

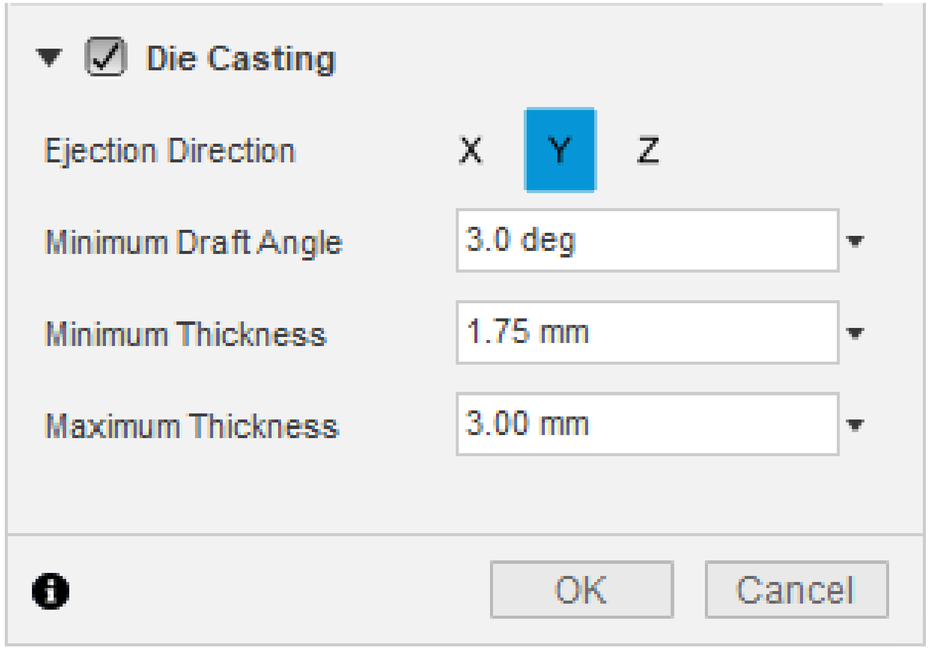


Figure 12: Die Casting Settings

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

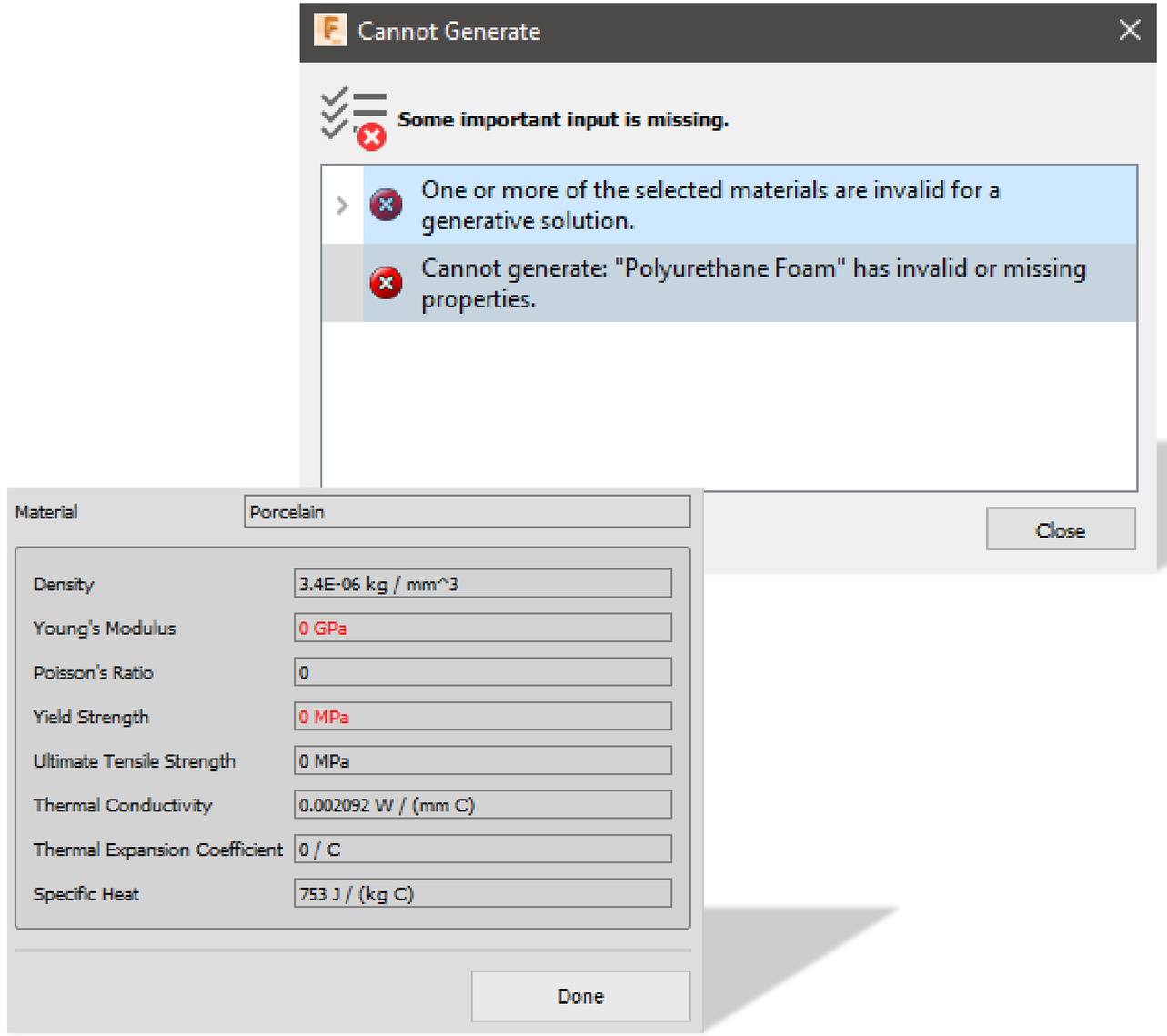
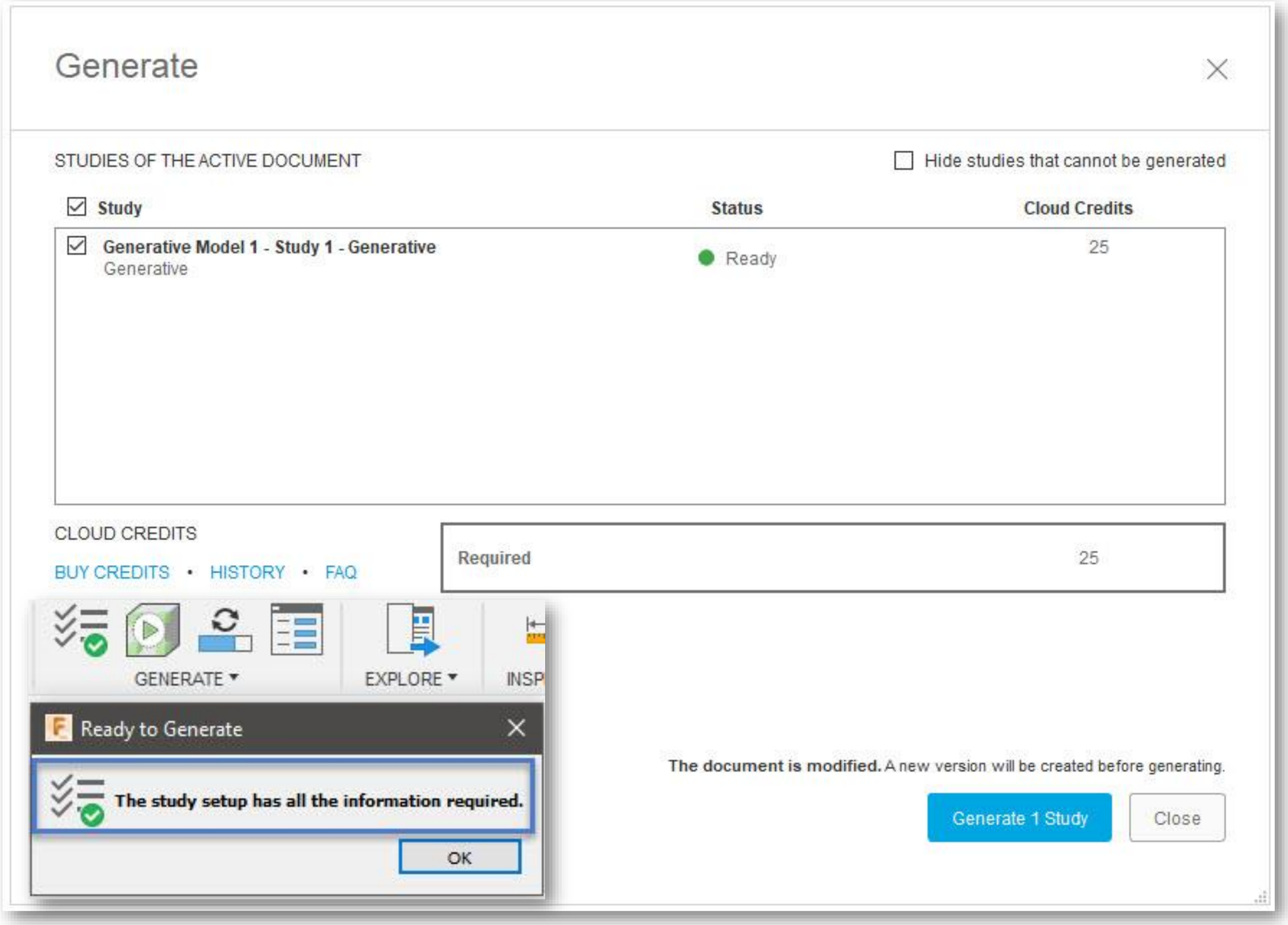


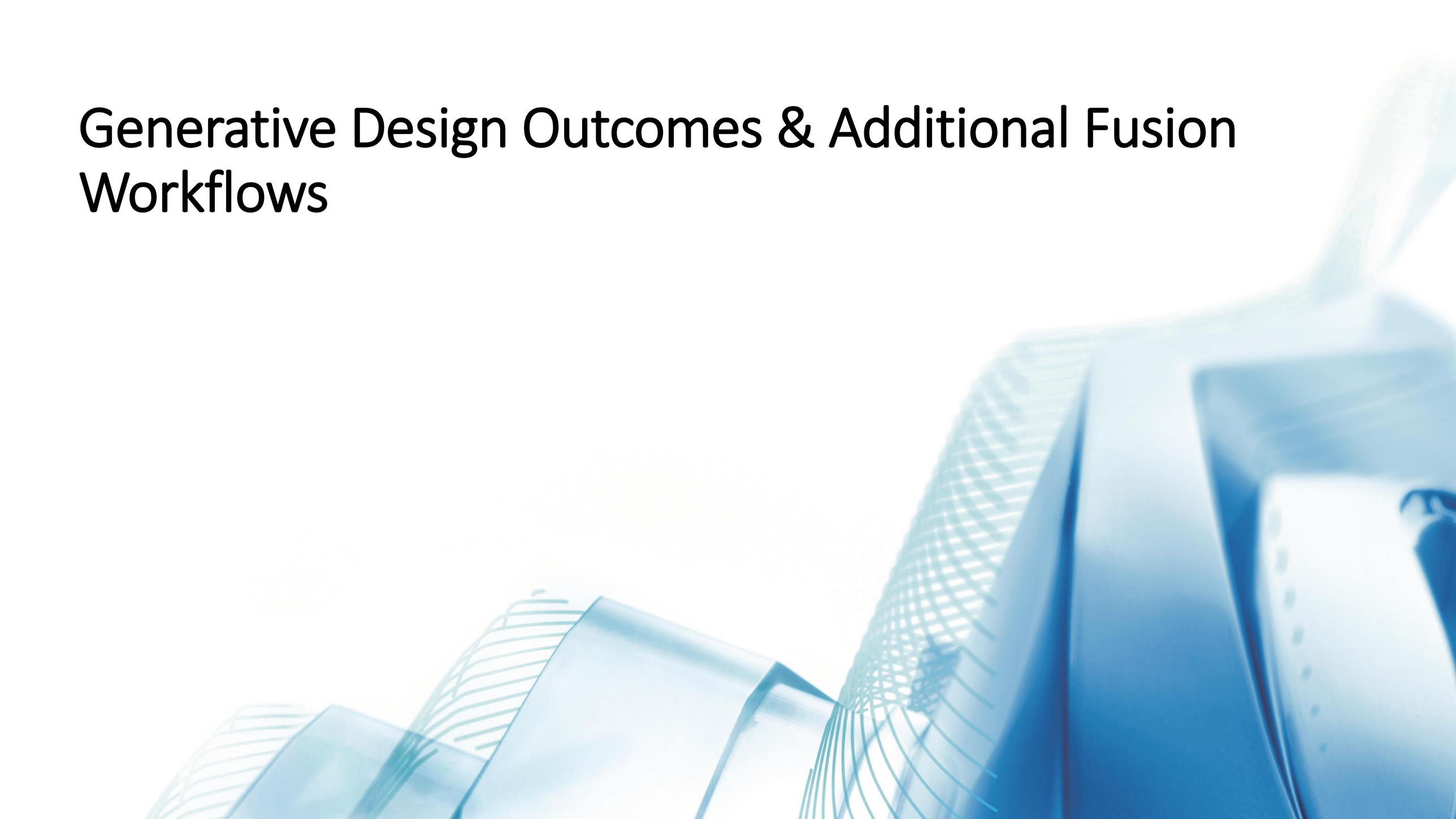
Figure 13: Invalid Materials

Pre-Check and Generate!

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

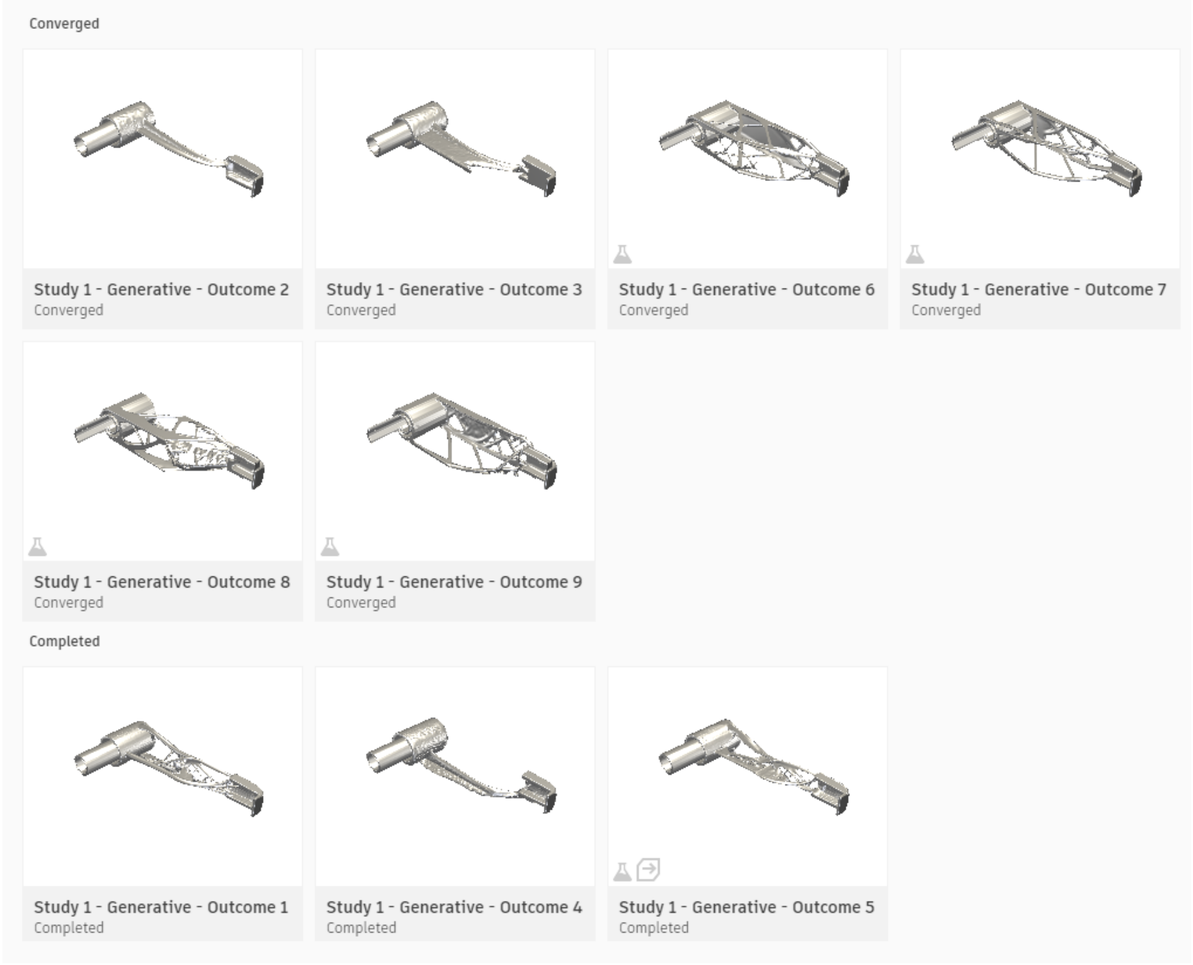


Generative Design Outcomes & Additional Fusion Workflows



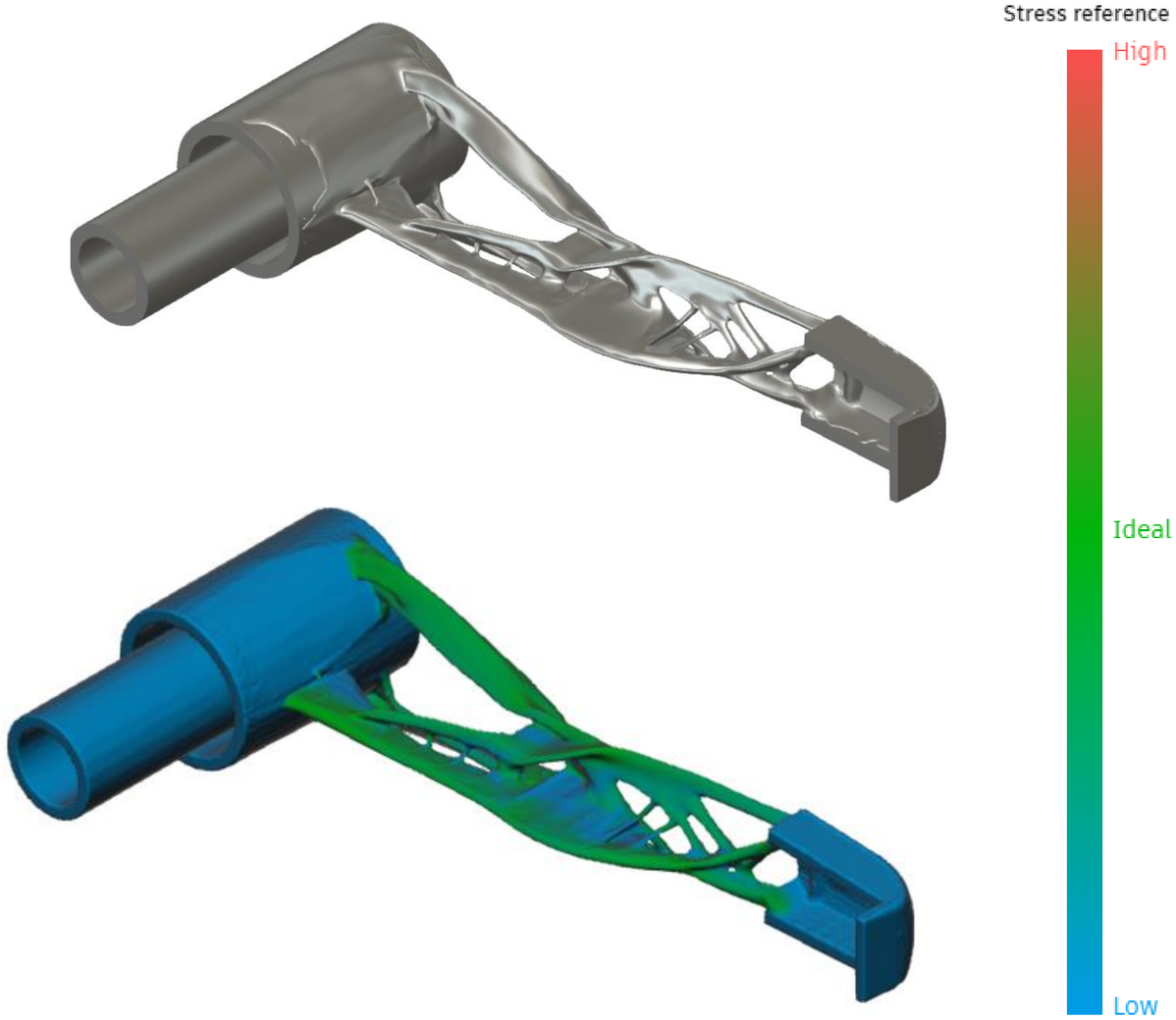
Explore Designs and Export

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



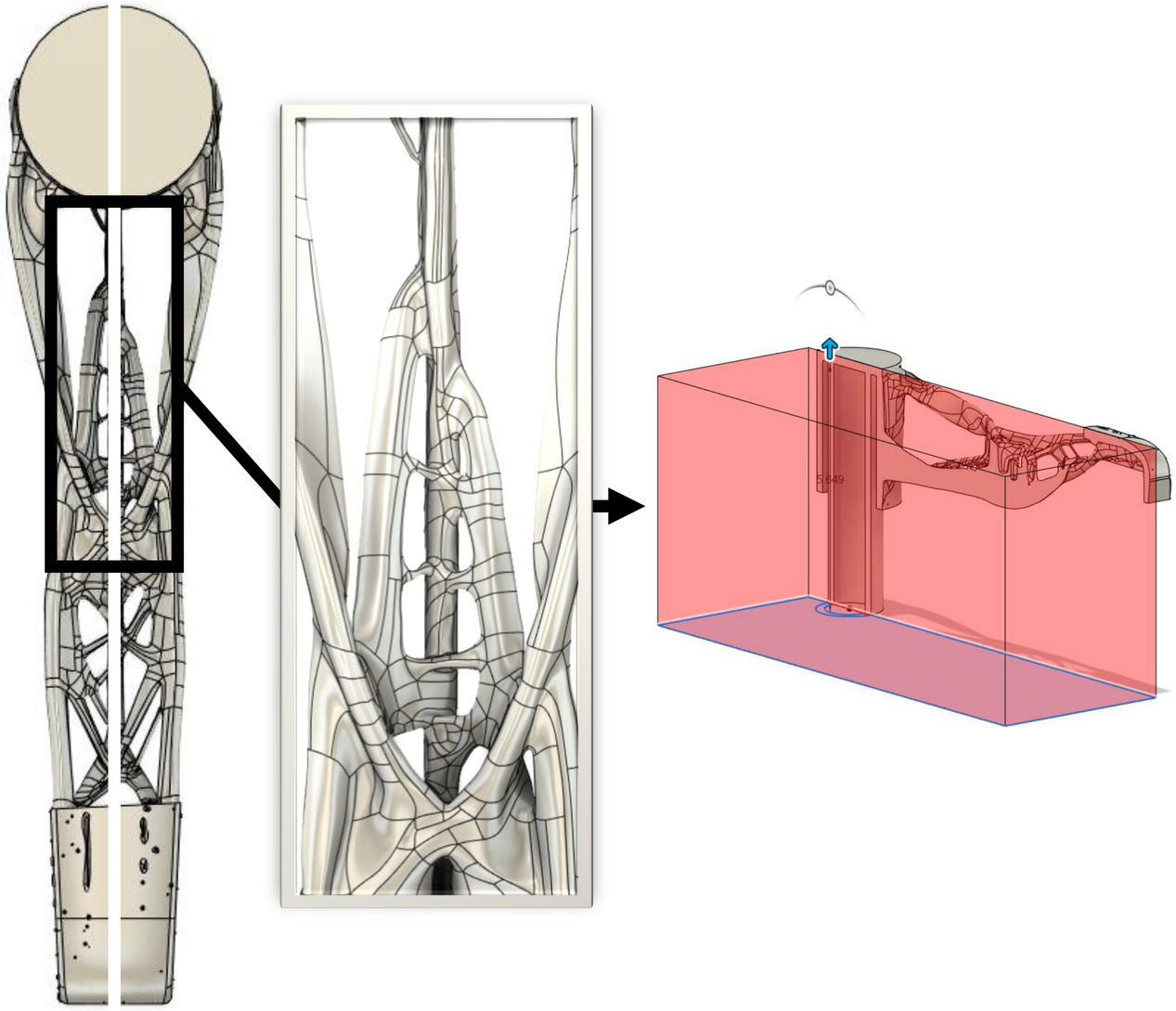
Create New Design from Outcome

- 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



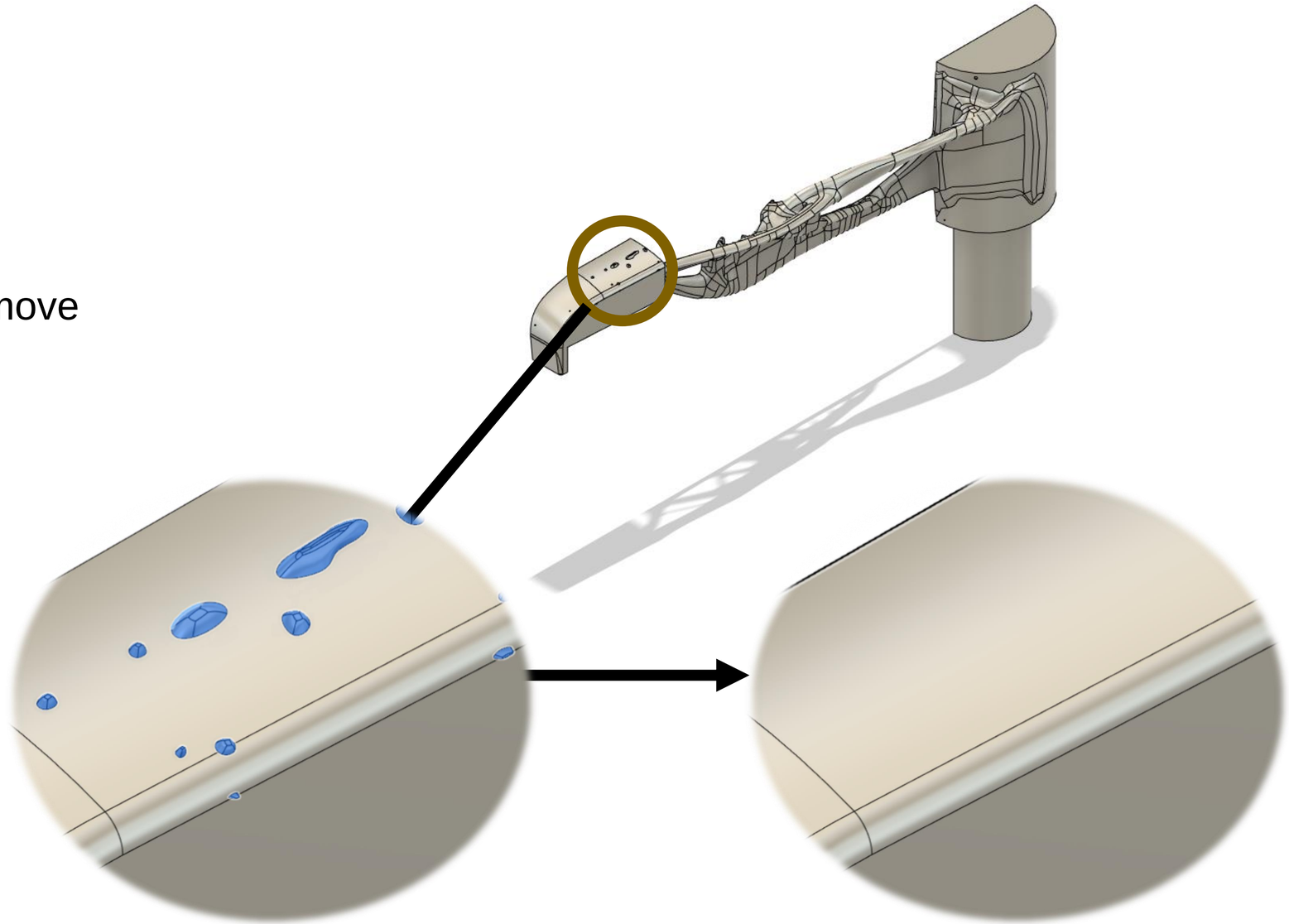
Symmetrical Design

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



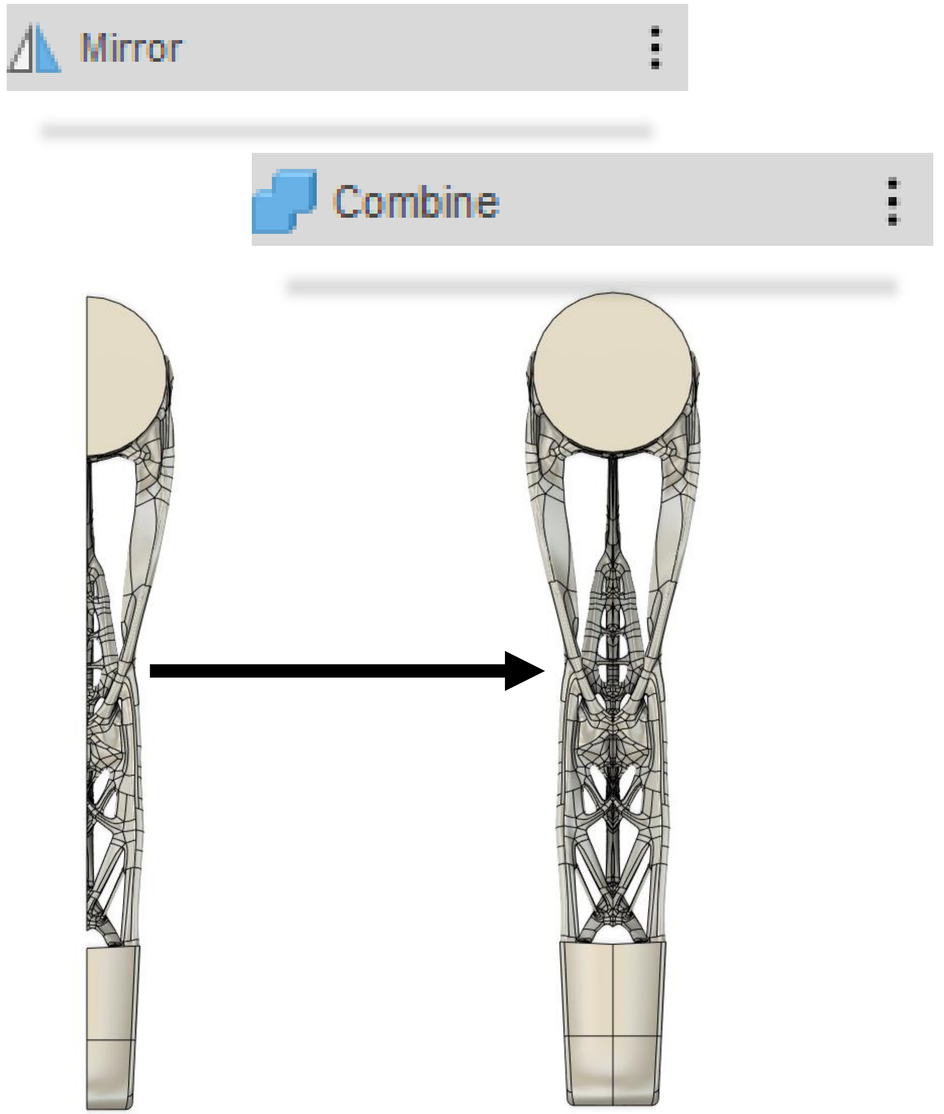
Modify Generatively Designed Geometry

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



Mirror and Combine

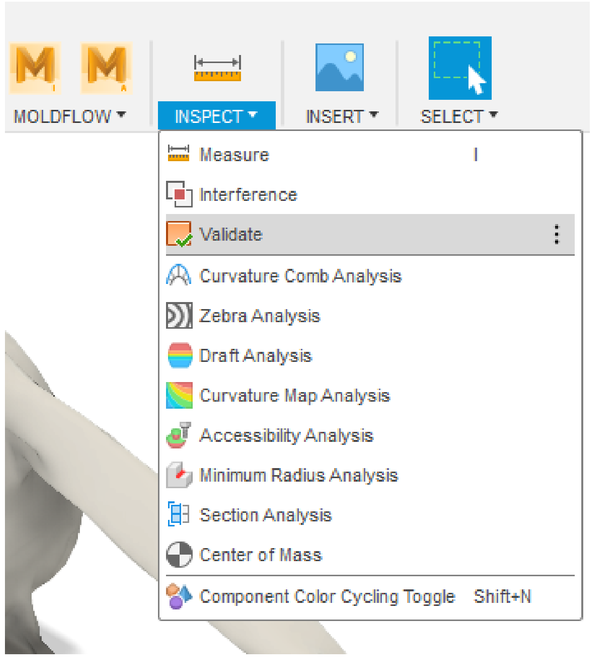
- Mirror modified body
- Combine both bodies
- Ensure all un-needed surface geometry is nonexistent

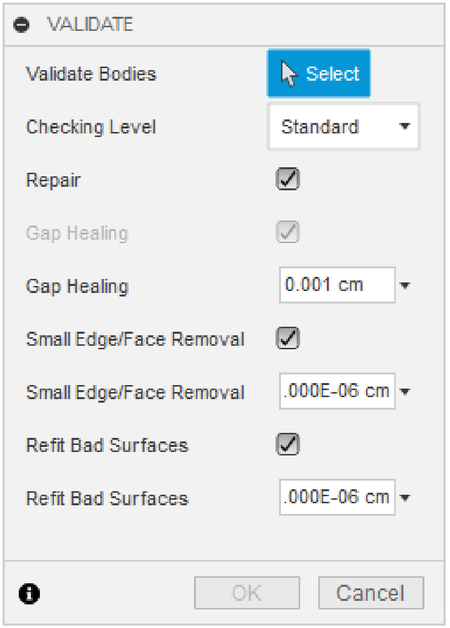


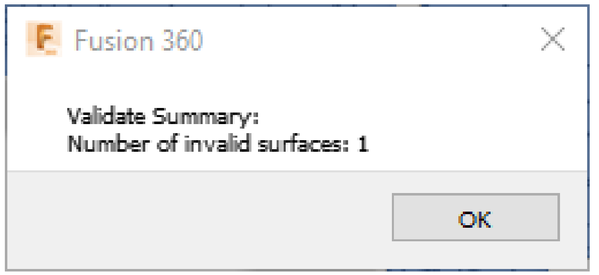
Validation & Repair in Fusion

- 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)*

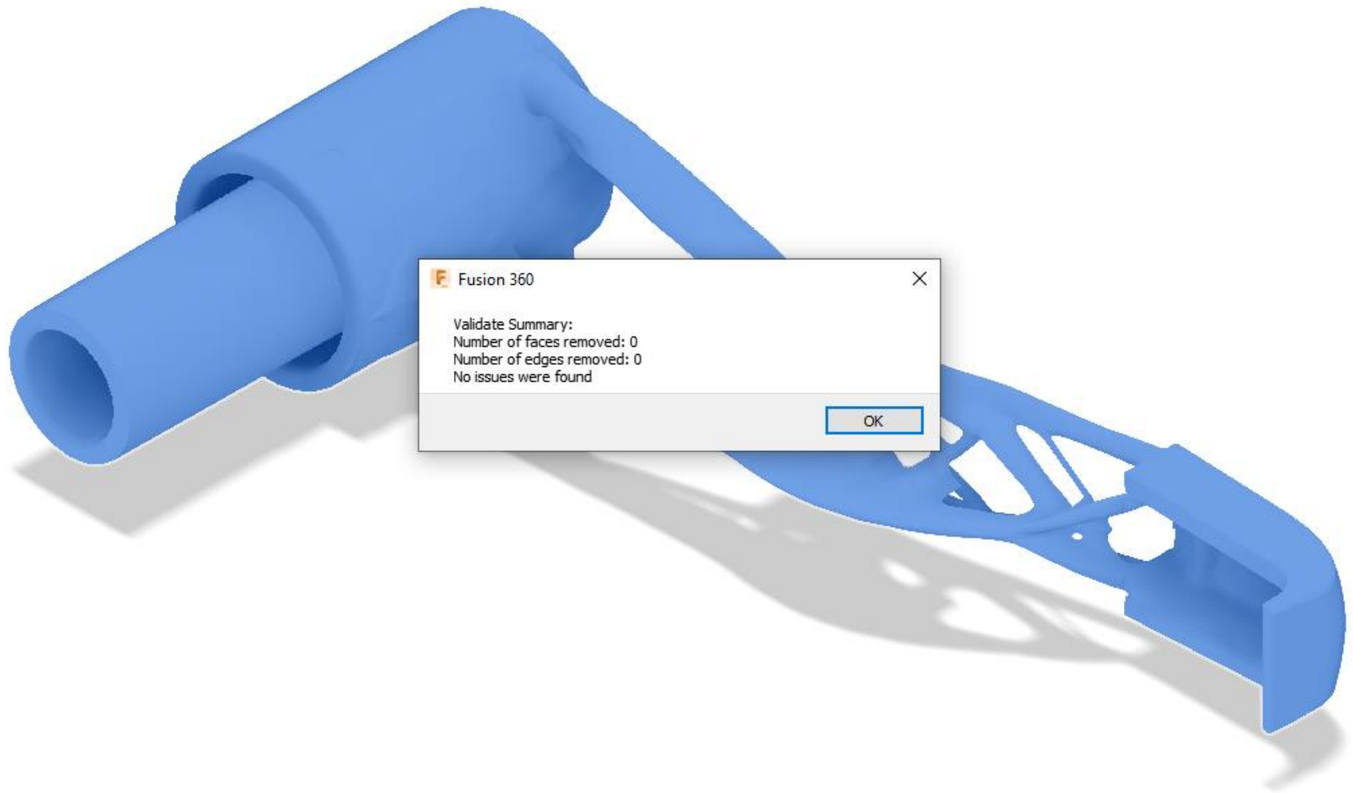




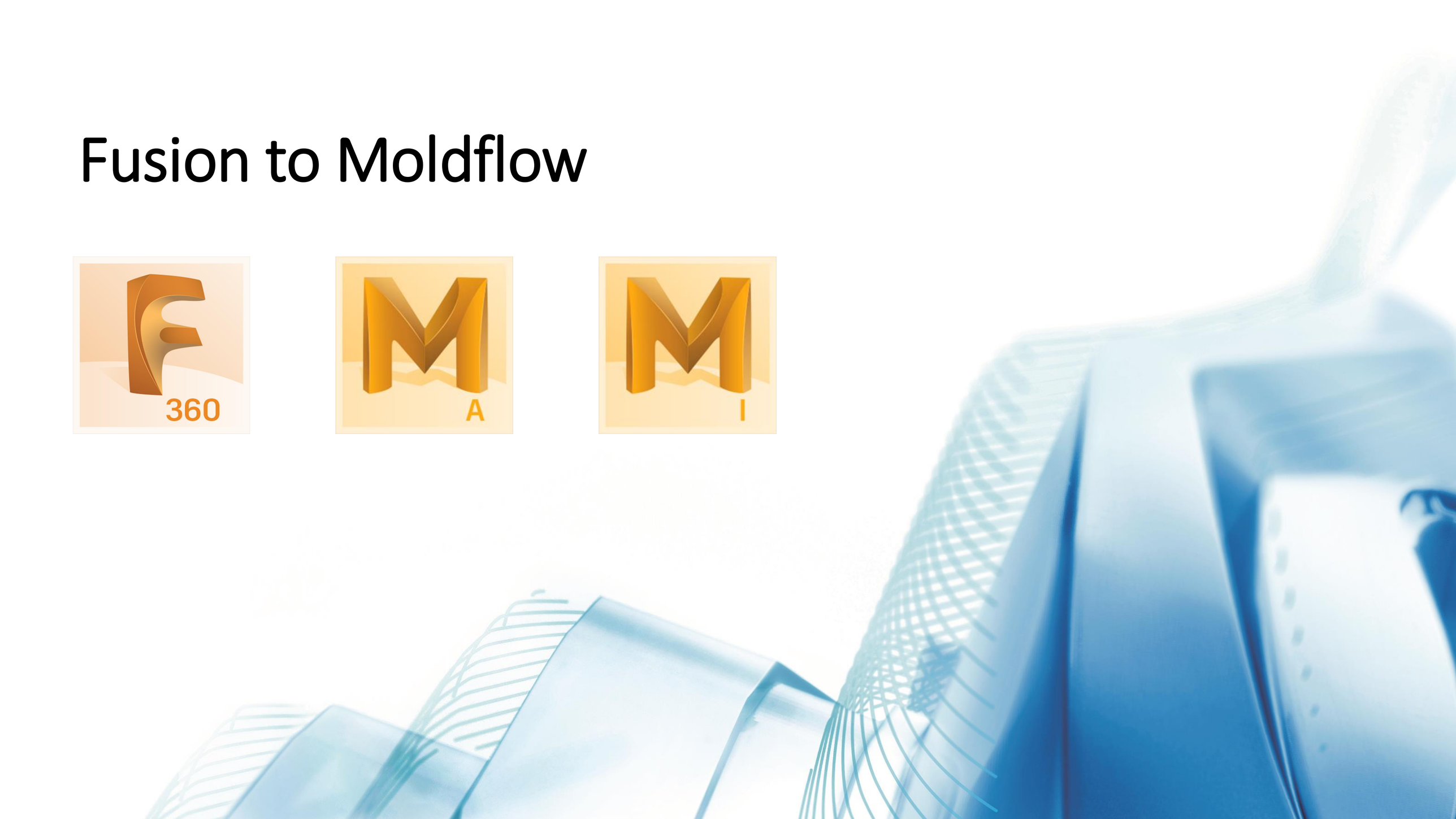


Validation in Fusion (again)

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

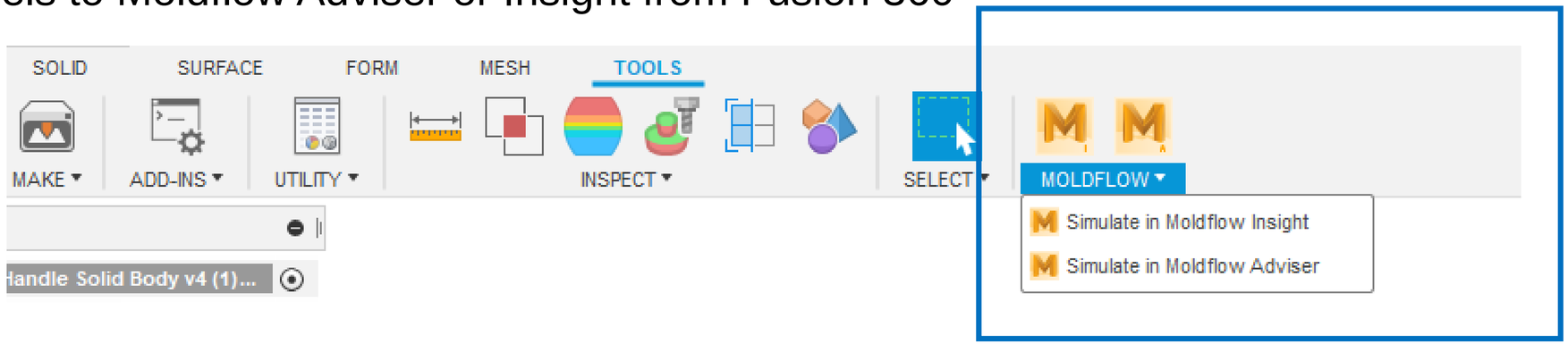


Fusion to Moldflow

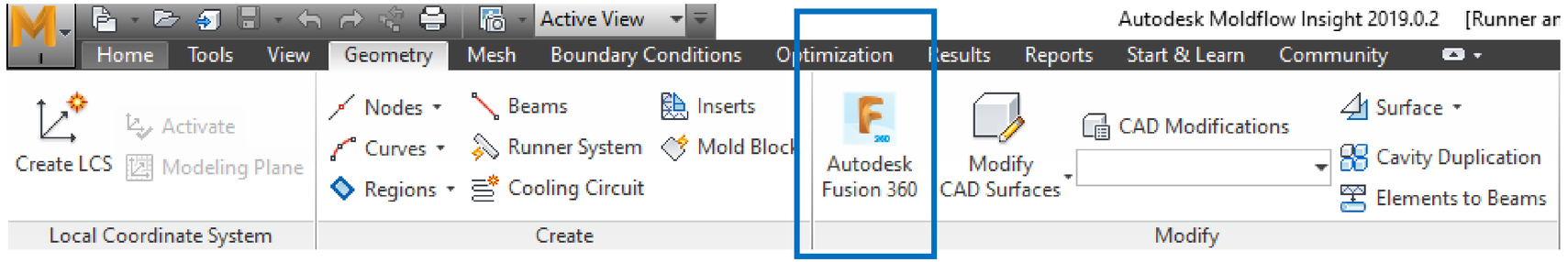


Connected Workflows Between Fusion & Moldflow

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



- Send models from Moldflow Insight back to Fusion 360

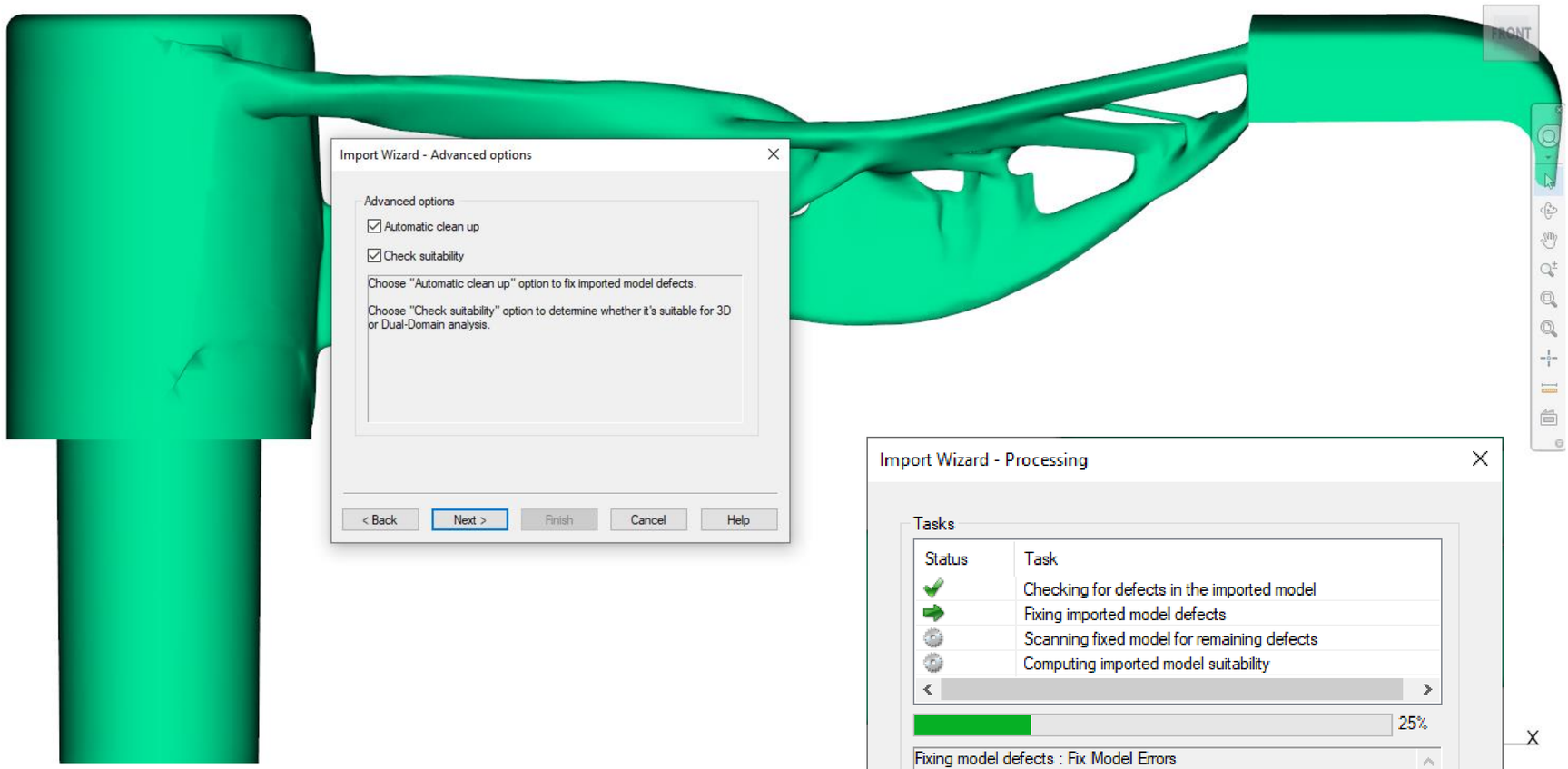


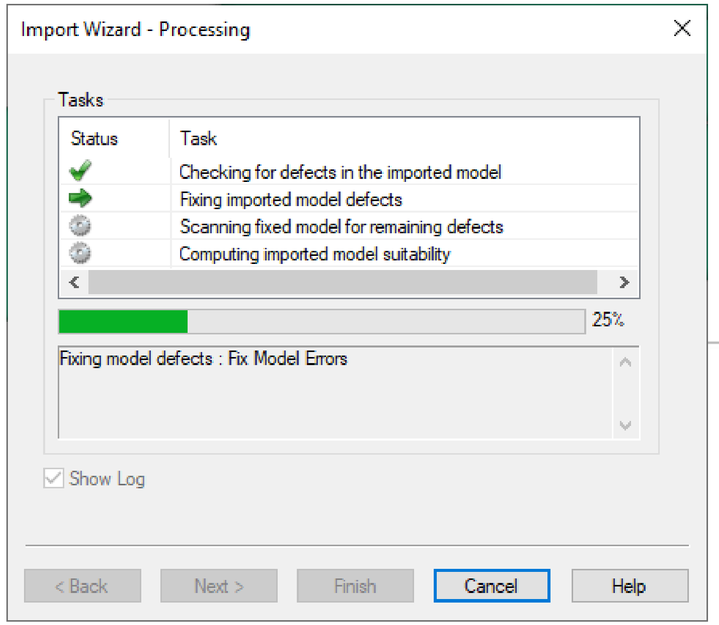
Autodesk Moldflow Injection Molding Software

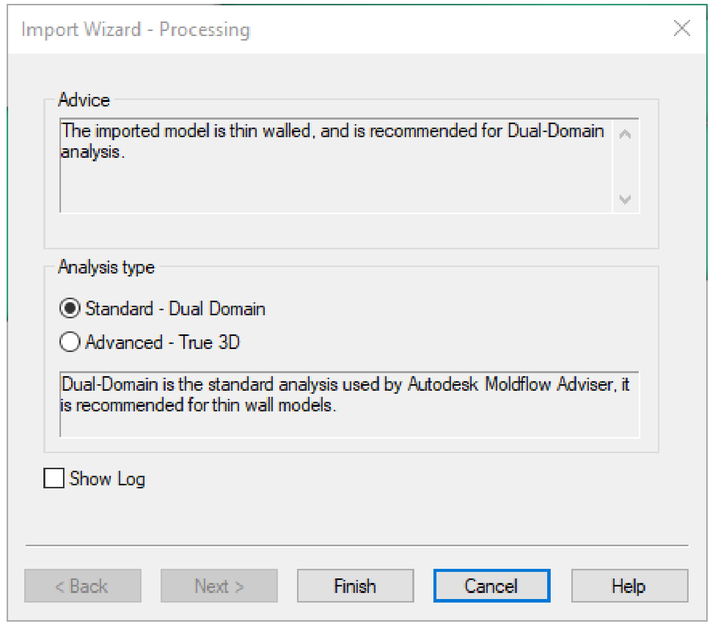
- **Autodesk Moldflow Adviser**
  - Part and Mold Design for Manufacturability
  - Injection Molding Thermoplastics Only
  - Ideal for Plastic Part Designers

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

Moldflow Adviser Import & Additional Model Checks

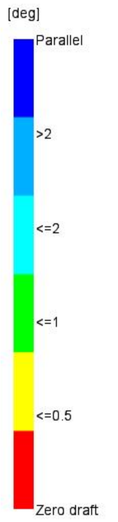


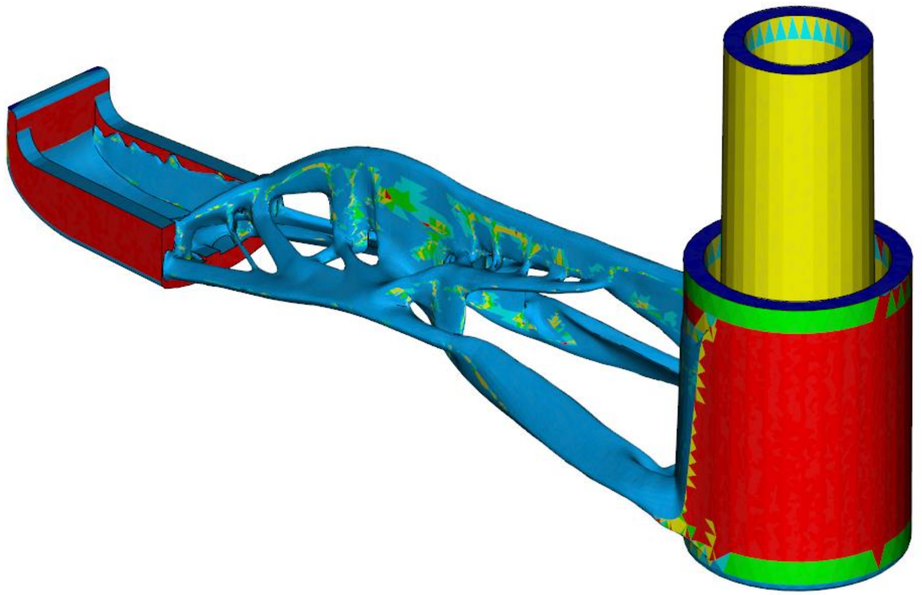




Design Adviser – Draft Angle

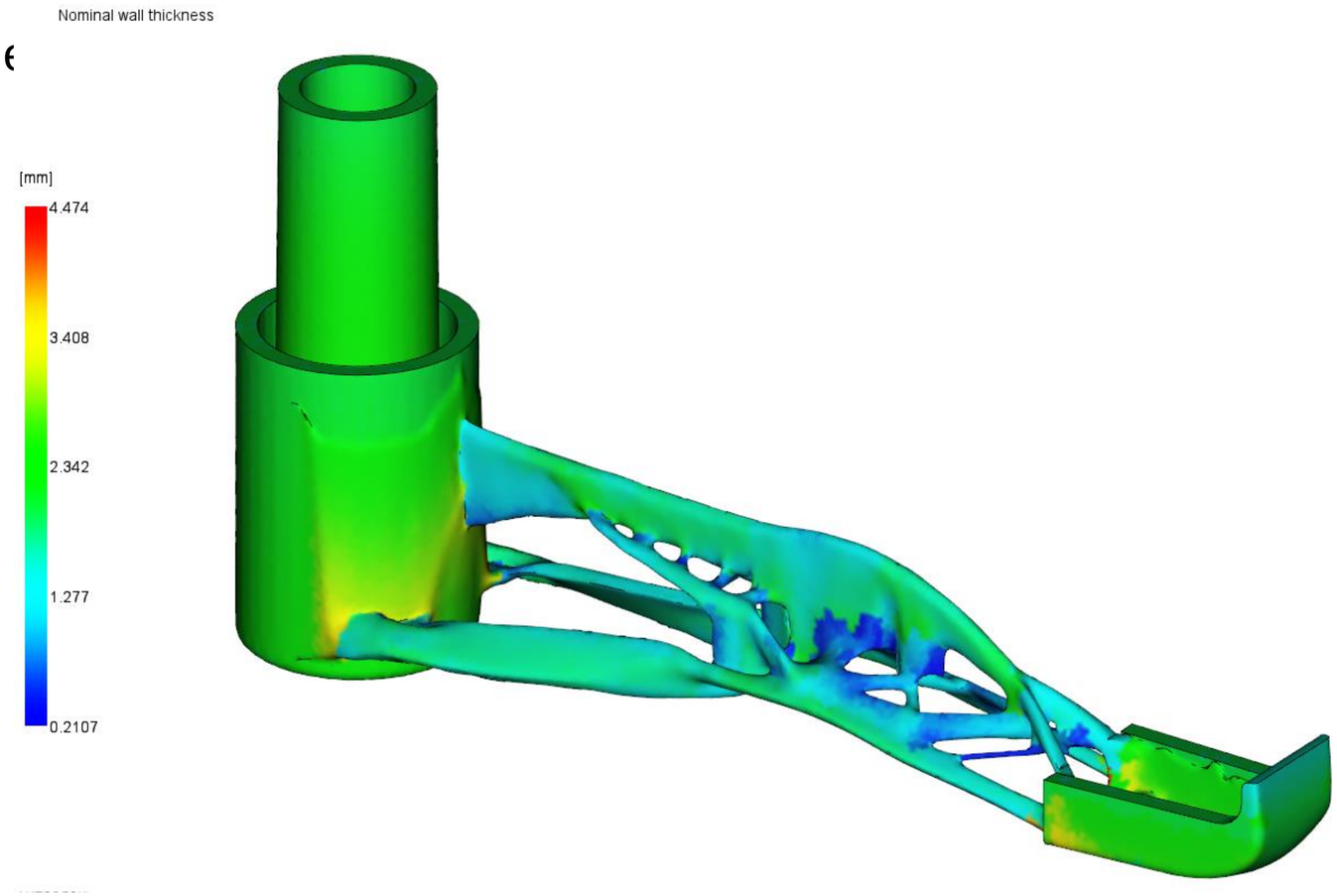
- The Draft Angle result displays draft variations
- As injection molded parts cool and shrink, they tend to shrink more on cores or male forms in the mold. This makes ejection difficult if draft is not included in the design
- Z+ Axis within Moldflow Adviser determines die draw or mold open vector





Design Adviser – Nominal Wall Thickness

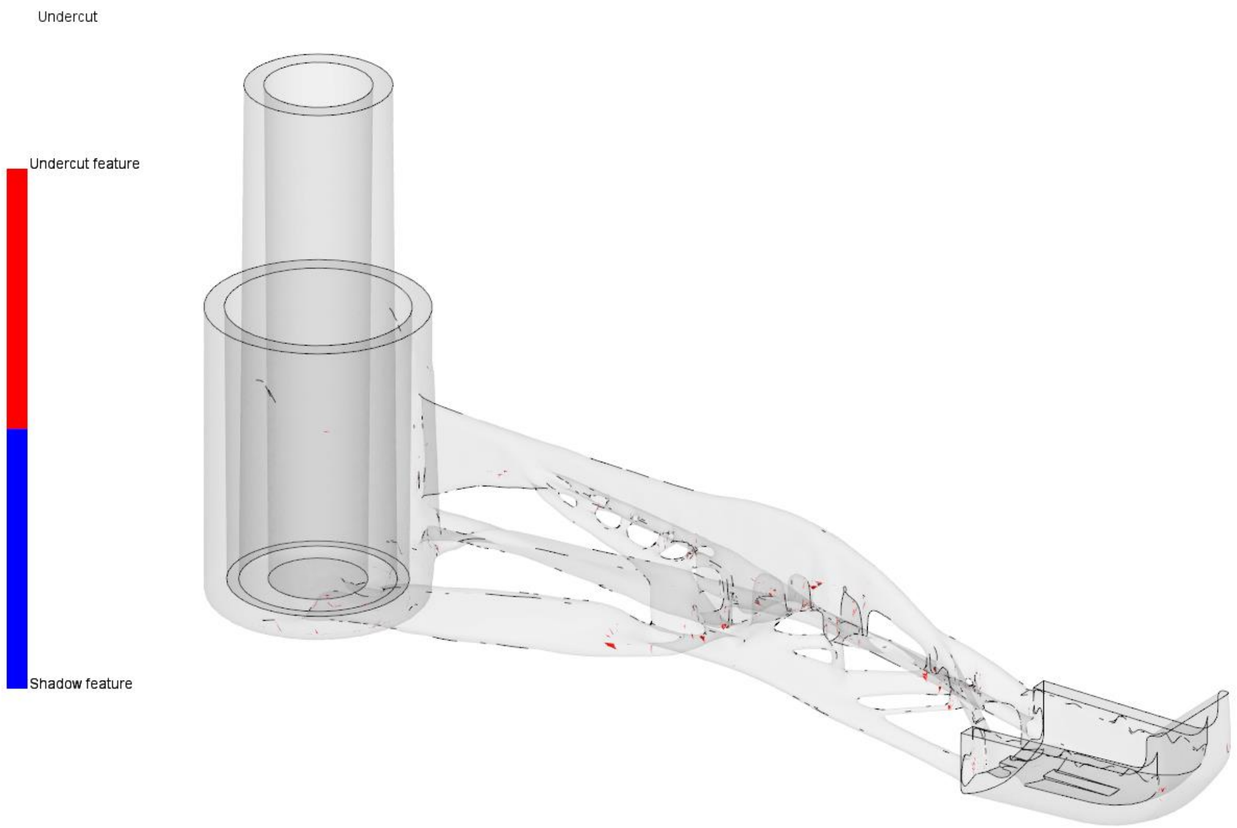
- The Nominal wall thickness result displays thickness variations relative to the wall thickne of the part.



Design Adviser – Undercuts

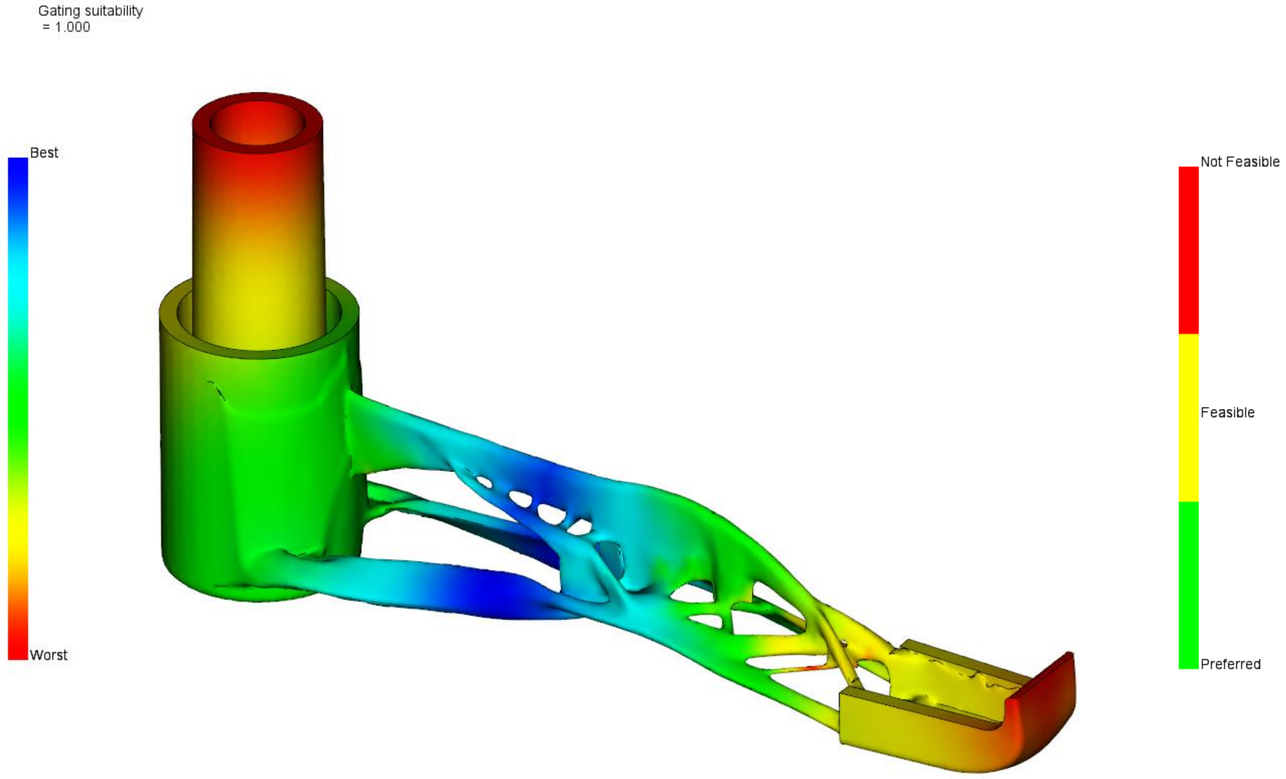
- The Undercut result displays areas where undercuts are located.

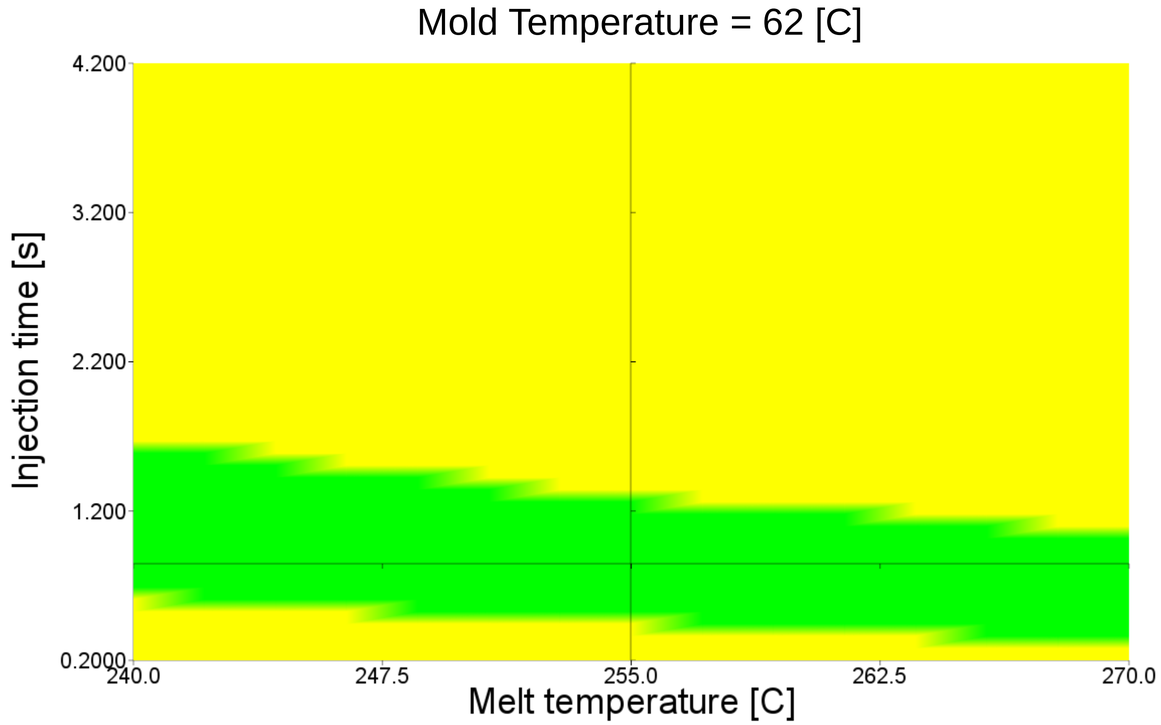
- Undercuts are either mistakes in the model or features in the tool that require special tooling components such as sliders, lifters or collapsing cores, for the part to be ejected.



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

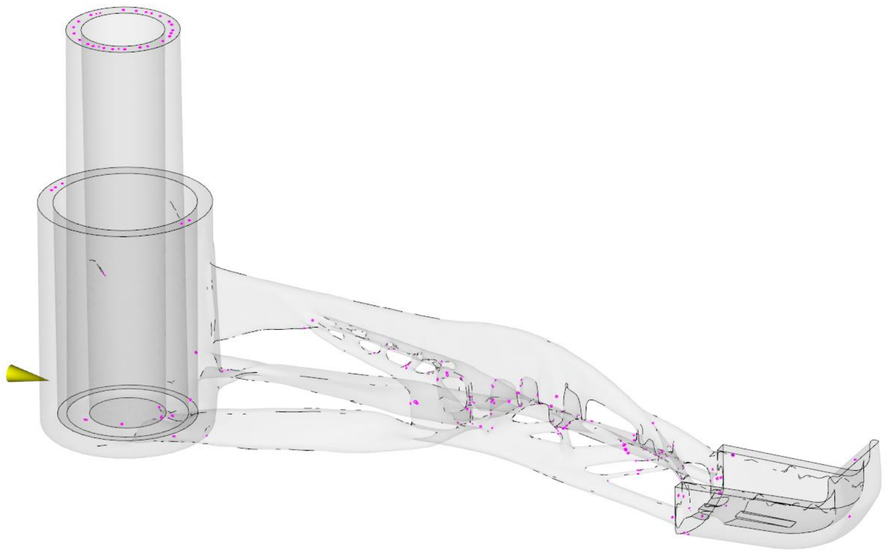




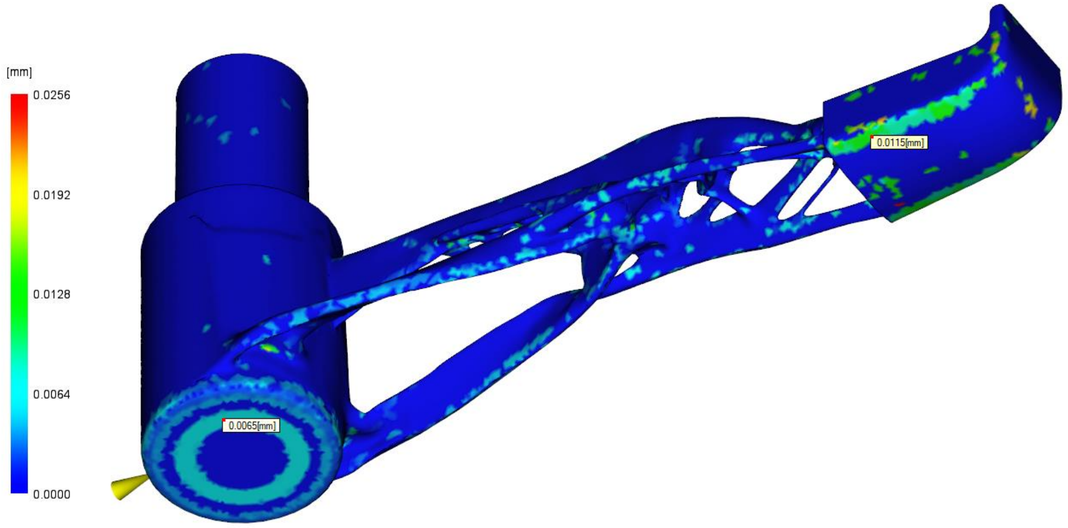
Additional Part Only Simulation Results

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

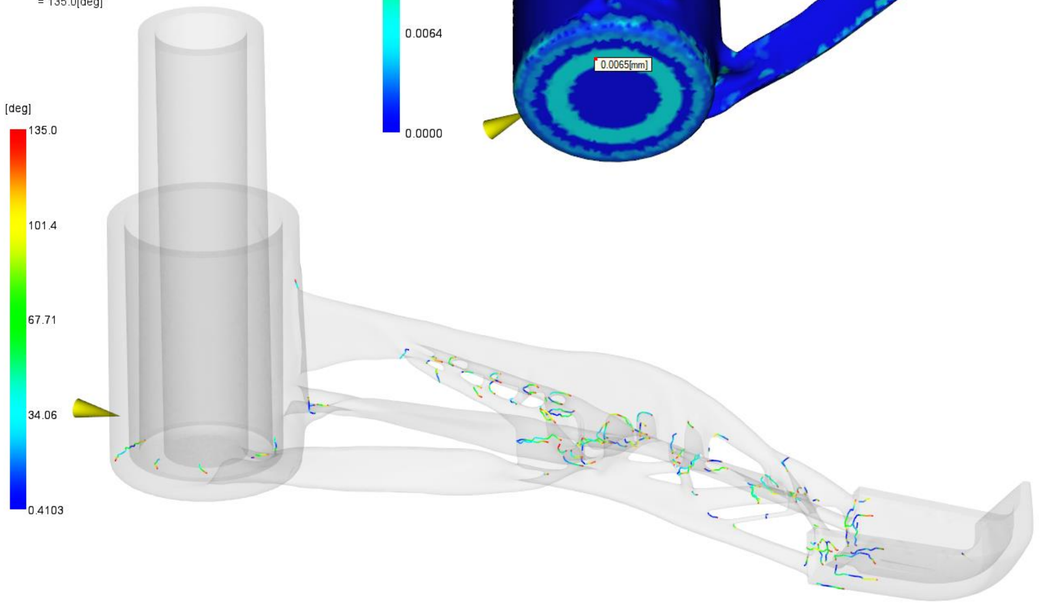
Air traps



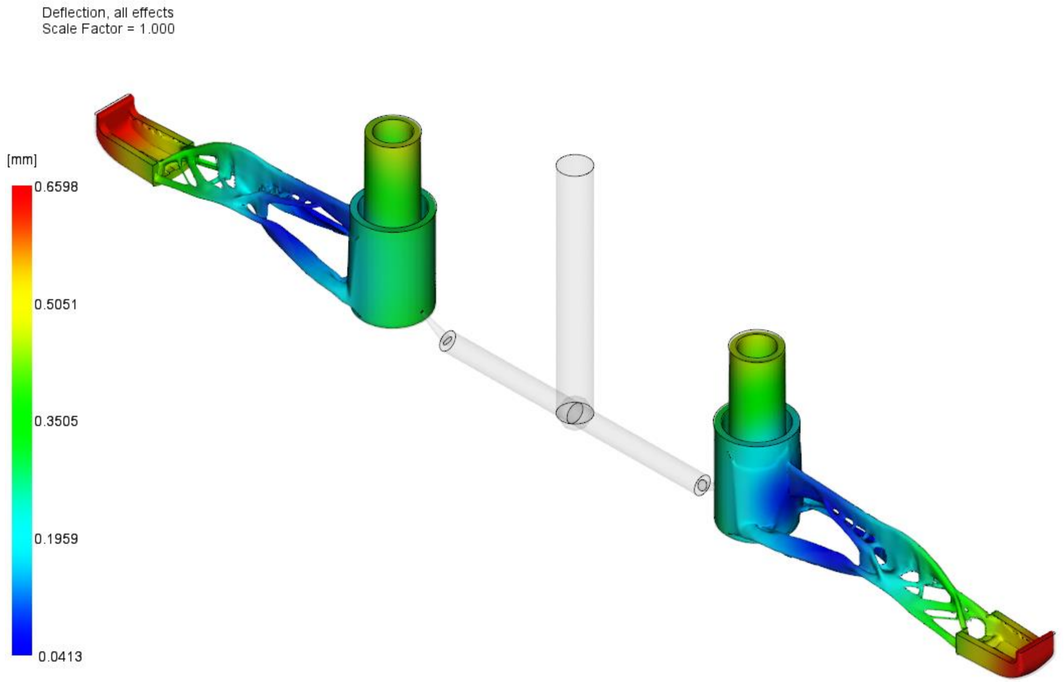
Sink marks estimate
Scale Factor = 1.000

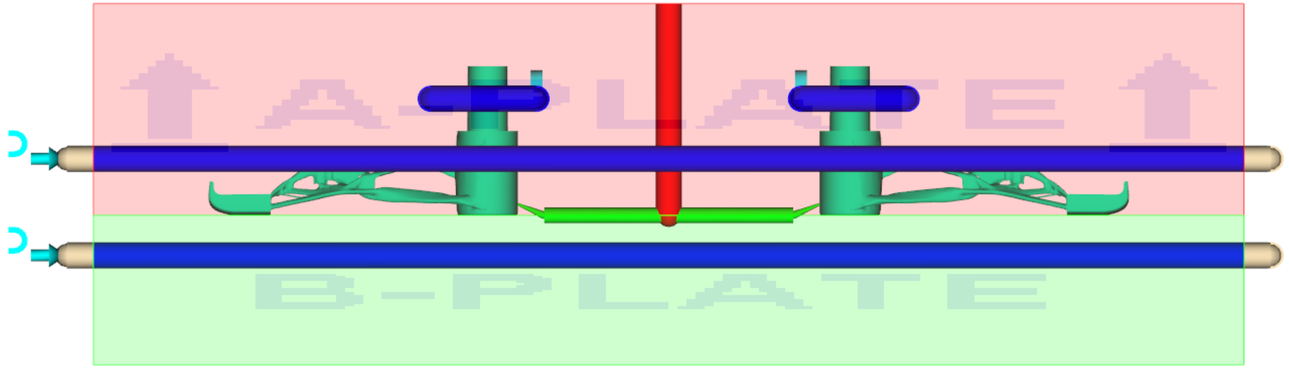


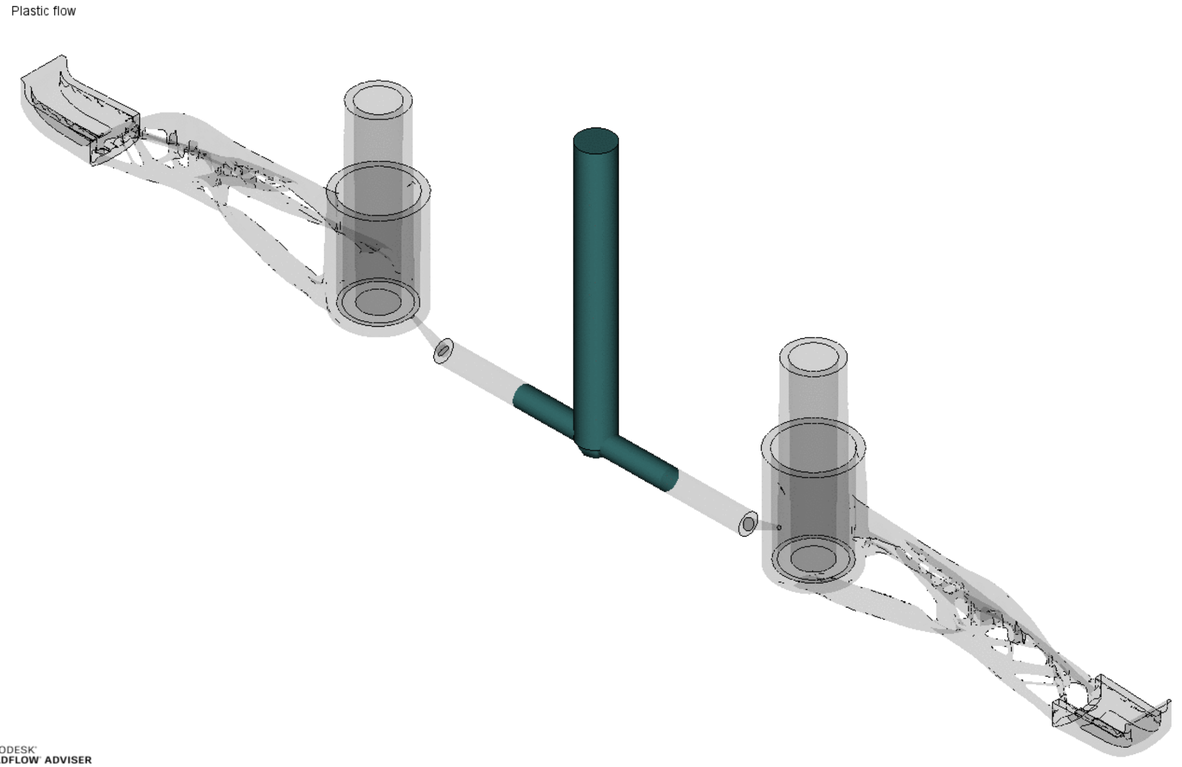
Weld lines
= 135.0[deg]



Cool+Fill+Pack+Warp Analysis

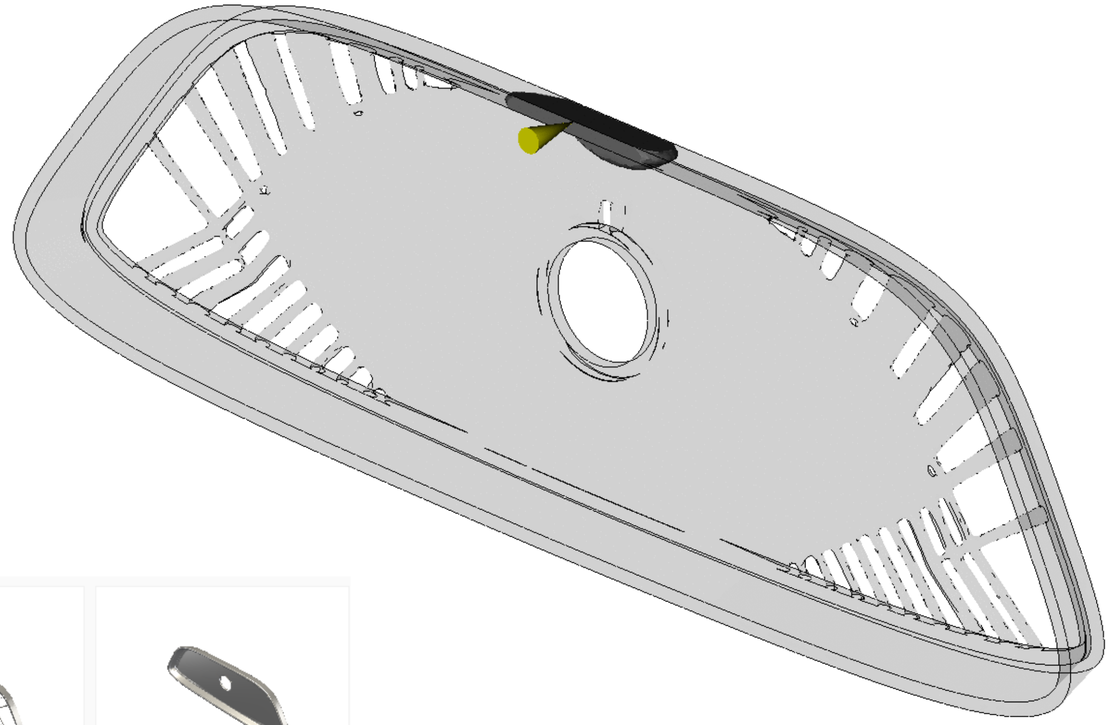


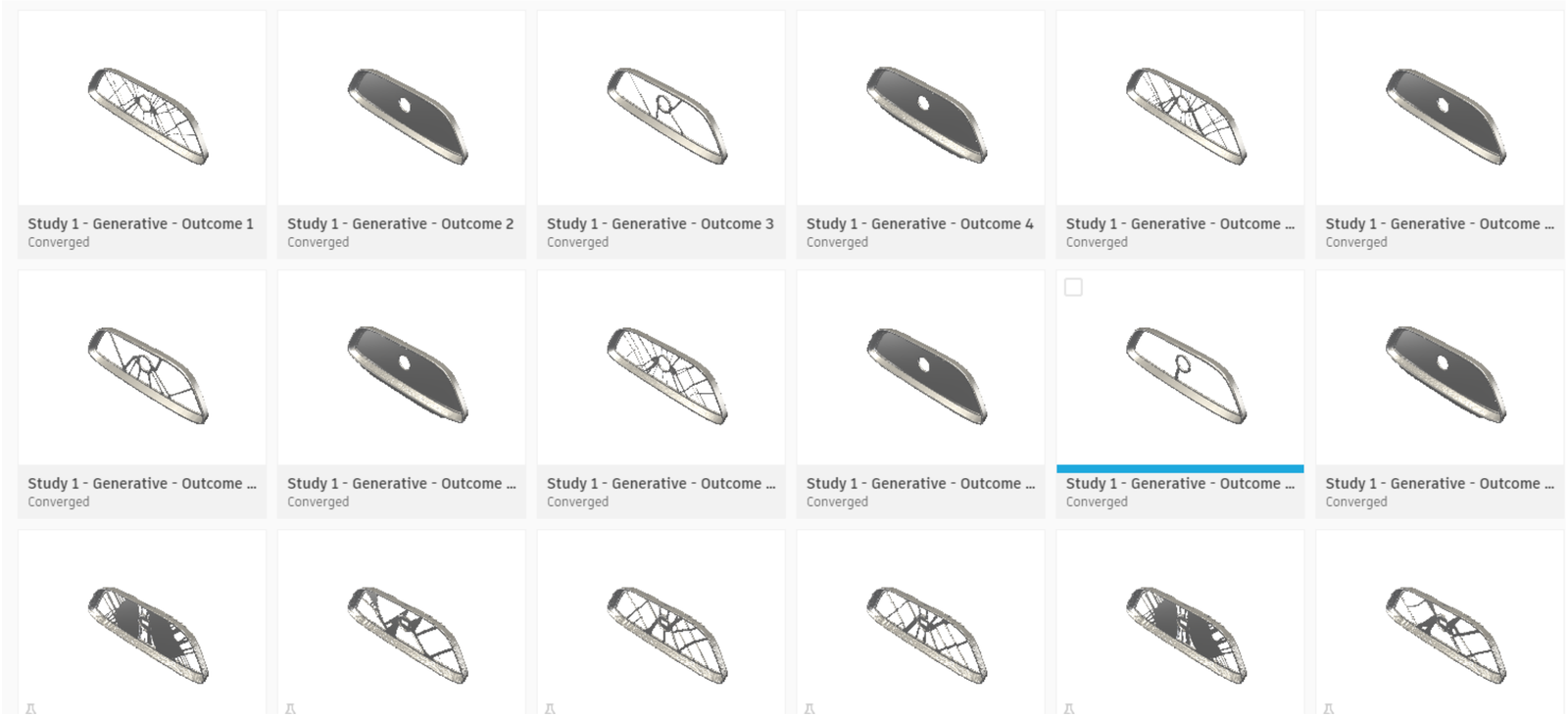




Fill time

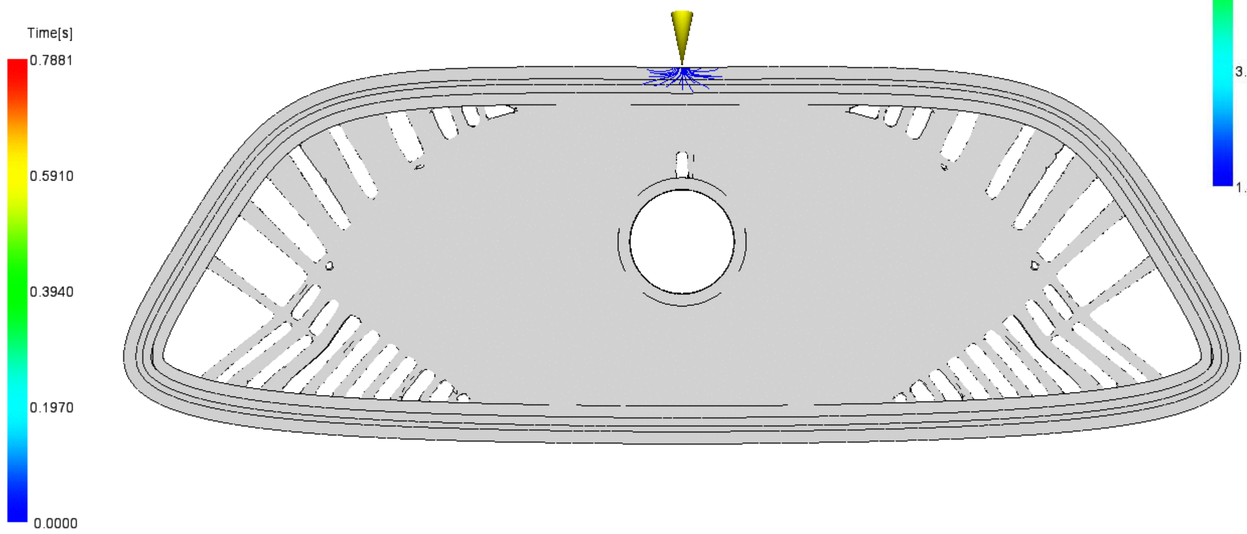
Generative Design for Plastic Housing



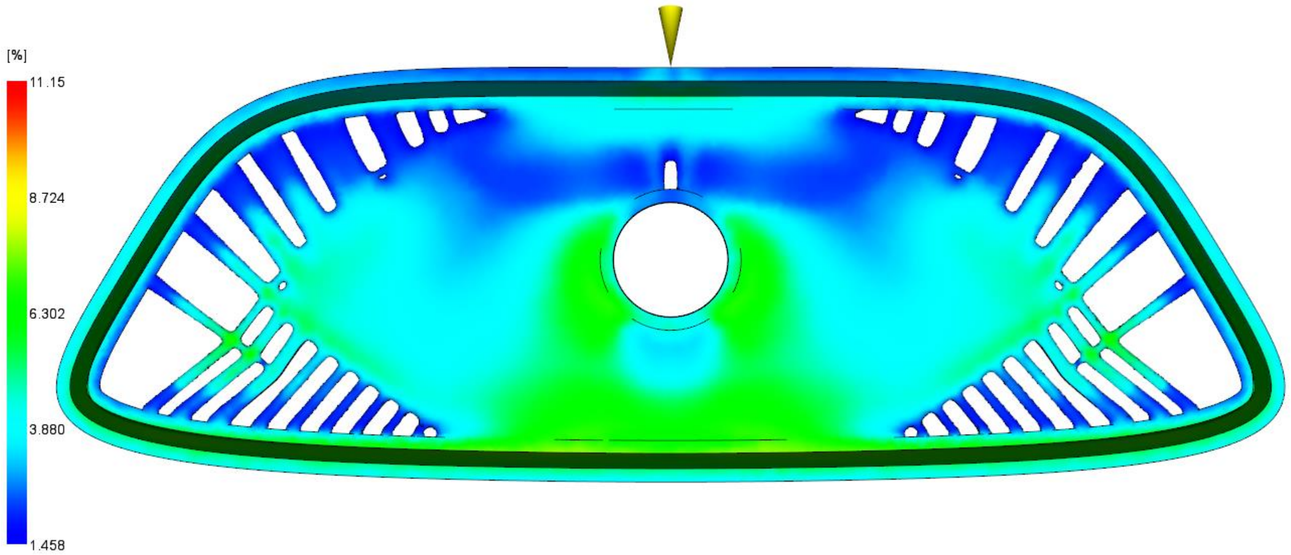


Moldflow Insight – Thermoplastic Results

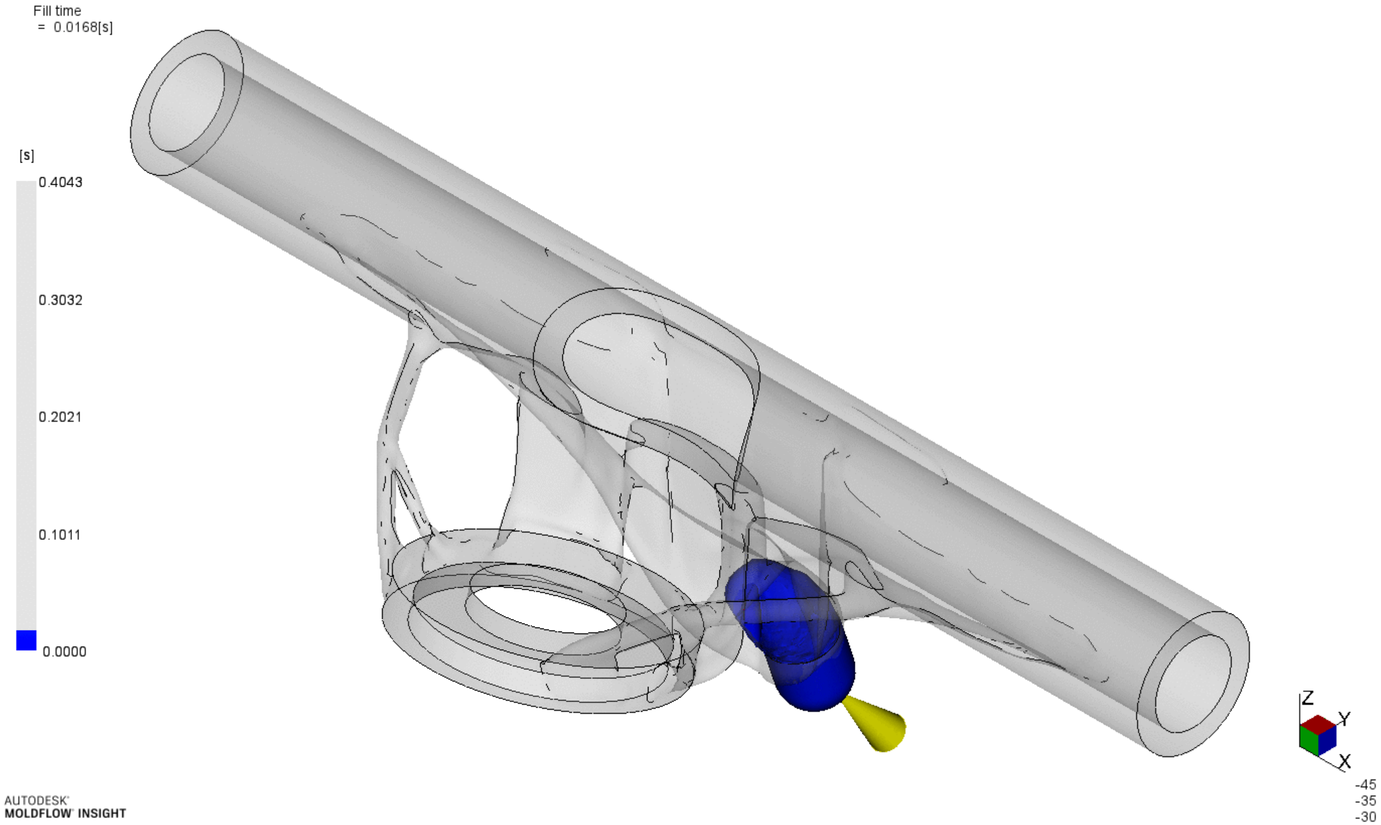
Pathlines
Time = 0.0000[s]



Average volumetric shrinkage
Time = 28.77[s]



Generative Design for Powdered Metal Injection Molding




Study 1 - Generative - Outcome 1
1.888e+4 mm³


Study 1 - Generative - Outcome ...
1.893e+4 mm³


Study 1 - Generative - Outcome ...
1.978e+4 mm³


Study 1 - Generative - Outcome ...
1.983e+4 mm³


Study 1 - Generative - Outcome 5
2.093e+4 mm³


Study 1 - Generative - Outcome ...
2.358e+4 mm³


Study 1 - Generative - Outcome 2
2.395e+4 mm³


Study 1 - Generative - Outcome ...
2.54e+4 mm³


Study 1 - Generative - Outcome ...
2.712e+4 mm³


Study 1 - Generative - Outcome 3
2.939e+4 mm³


Study 1 - Generative - Outcome ...
3.031e+4 mm³


Study 1 - Generative - Outcome ...
3.05e+4 mm³


Study 1 - Generative - Outcome ...
3.196e+4 mm³

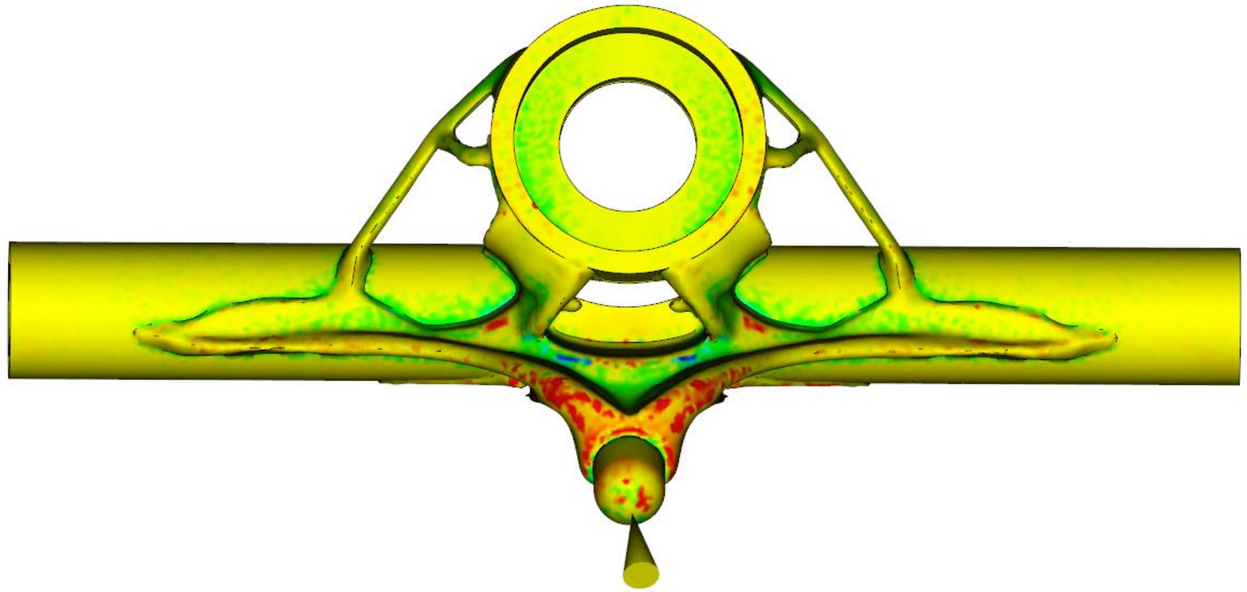

Study 1 - Generative - Outcome ...
3.263e+4 mm³


Study 1 - Generative - Outcome ...
3.371e+4 mm³

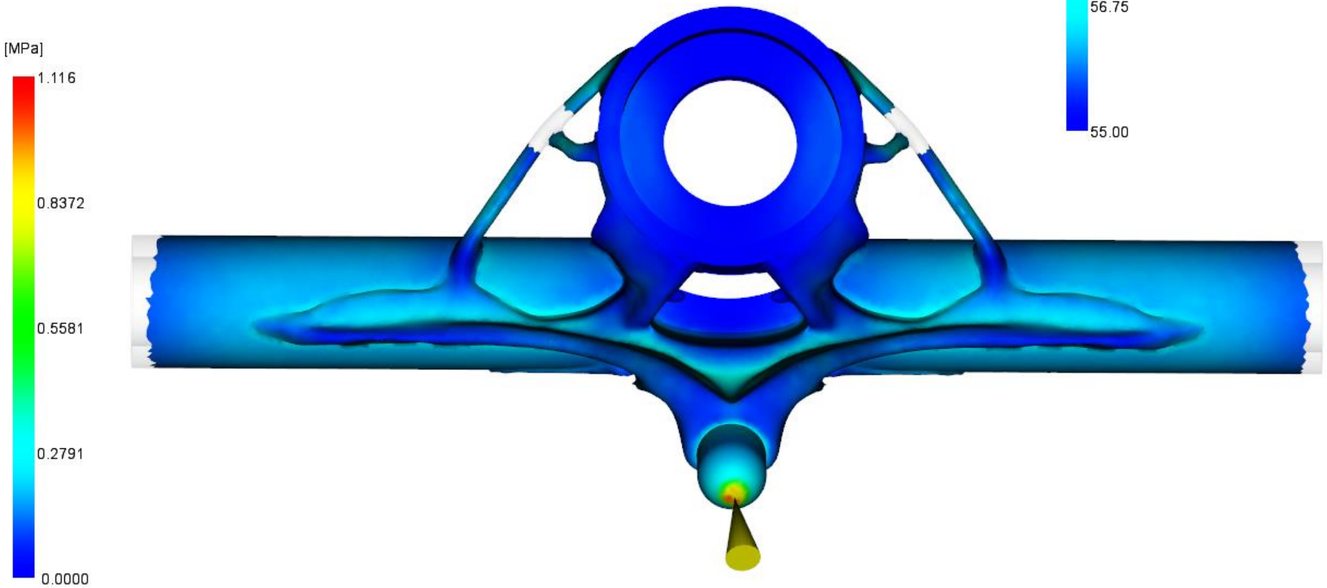

Study 1 - Generative - Outcome ...
3.393e+4 mm³

Moldflow Insight – Powder Metal Results

Powder volume concentration
Time = 30.39[s]



Shear stress at wall
Time = 0.3946[s]



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

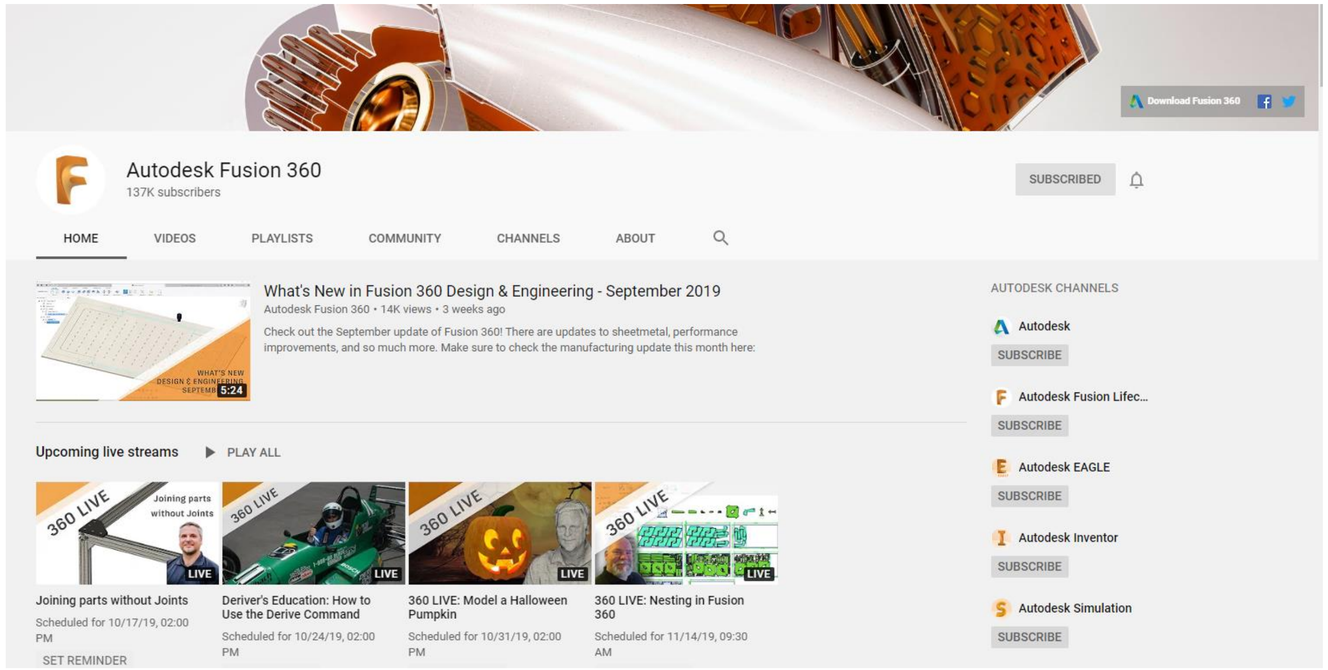
100 Cloud Credits Free with Trial Version

EXPLORE OTHER FUSION 360 RESOURCES

[Autodesk Fusion 360 – YouTube]

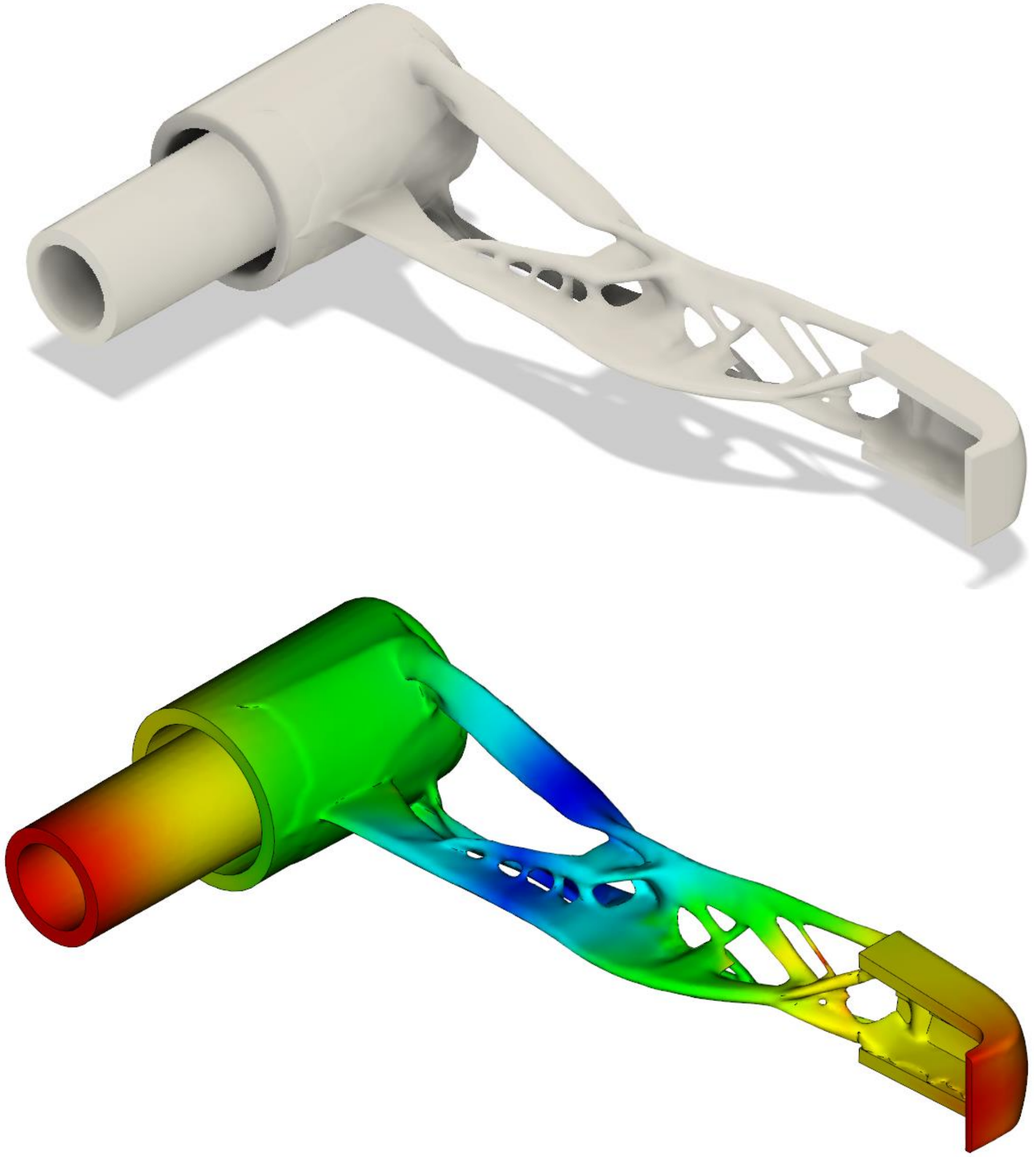
[Autodesk Academy]

Embedded Quick Tips & Tutorials



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.



AUTODESK®

Make anything™