

ACPA7001

Assessment A

Generative Design of a large Oil and Gas Flange
Component

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By

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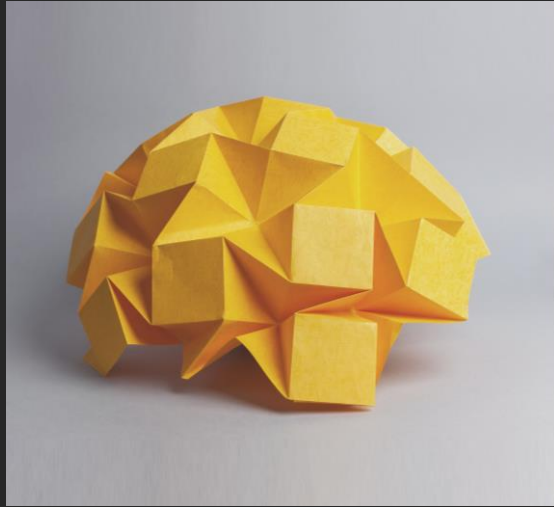
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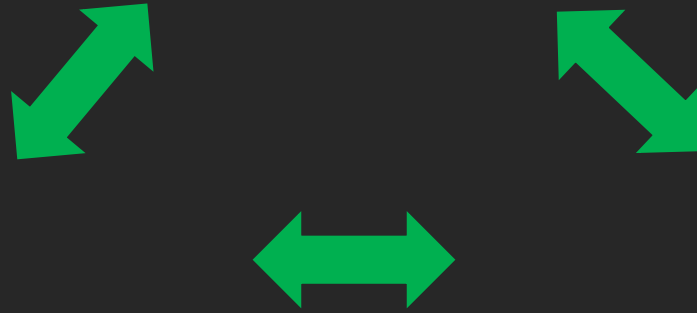
Agenda

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- ❑ Fusion 360 Overview
- ❑ Generative Design Principles
- ❑ Flange Components in Oil & Gas
- ❑ Flange Generative Design Steps
- ❑ Outcome Analysis
- ❑ Future Trends
- ❑ Conclusion
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Introduction



**Generative
Design**



**Oil & Gas
Industry**

Fusion 360 Overview

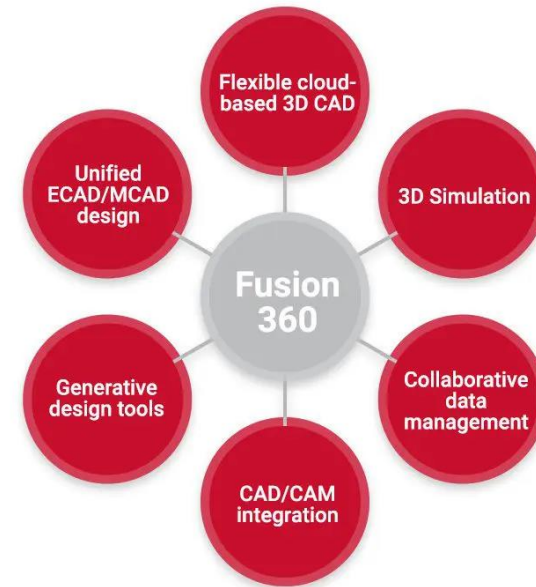
Autodesk Fusion 360 stands as a leading cloud-based CAD / CAM tool, renowned for its versatility in engineering applications.

Its significance in generative design lies in its seamless integration of advanced features.

Through generative algorithms, it explores vast design possibilities, optimising structures for various parameters.

Fusion 360 also offers robust simulation capabilities, enabling engineers to validate designs under diverse conditions.

(Song et al., 2018)



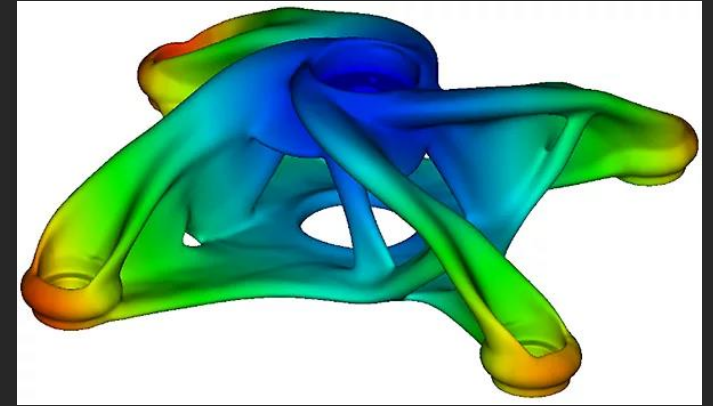
Generative Design Principles

Generative design is a revolutionary approach in engineering where algorithms autonomously explore and generate multiple design iterations, optimising for predefined objectives and constraints.

Its significance lies in its ability to enhance engineering efficiency, enabling engineers to create innovative and highly efficient designs.

Generative design minimises material usage, reduces weight, and often discovers unconventional yet functional designs, leading to more sustainable and cost-effective solutions in various industries.

(OH et al., 2019)



Flange Components in Oil & Gas

Designing efficient and reliable flange components in the oil and gas industry poses intricate challenges. Factors such as high-pressure conditions, varying temperatures, and corrosive environments demand precision.



Meeting safety standards while ensuring structural integrity amidst these conditions necessitates intricate engineering solutions.

(Olaizola et al., 2022)

Flange Generative Design Steps

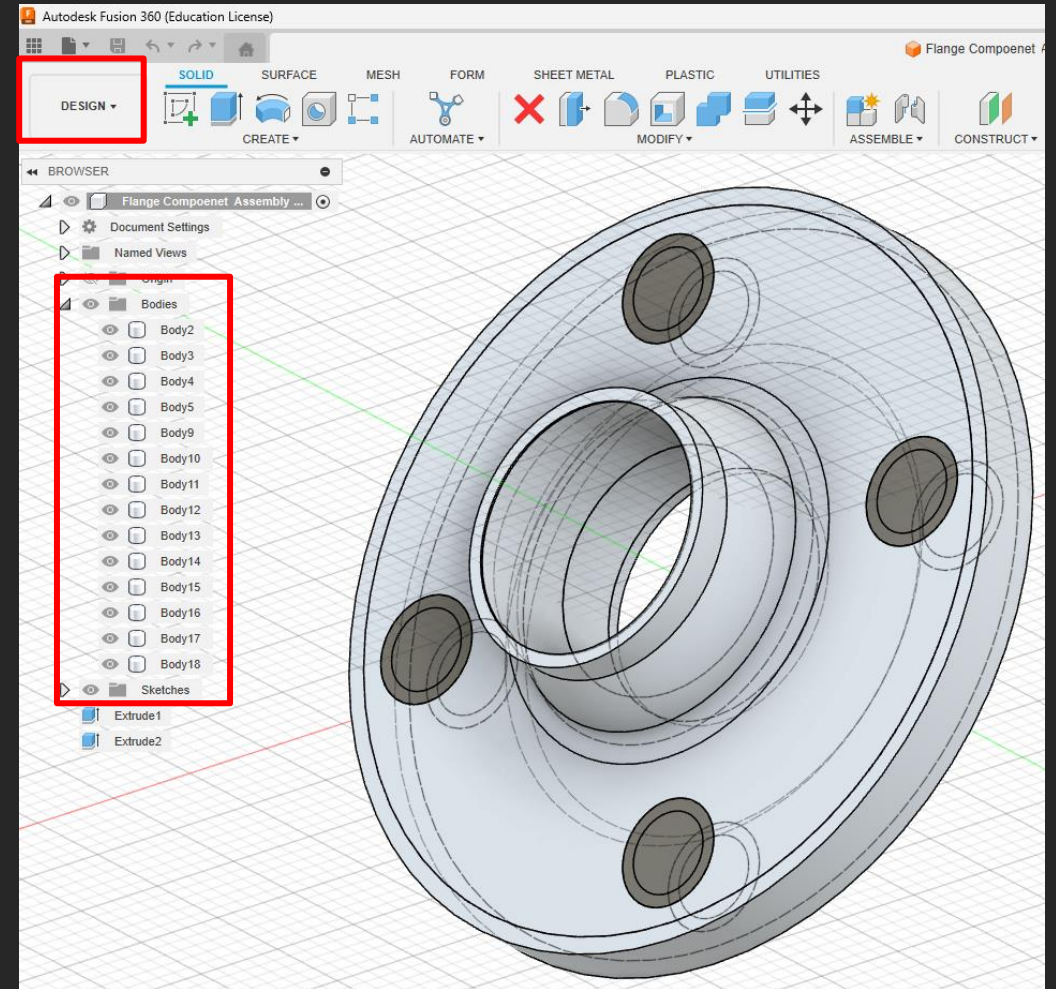
Step 1:

Used Design Workspace to draw and establish a solid flange component.

Step 2:

Split Flange into 14 subcomponent body parts to ensure full flexibility.

Then Back to Generative Design Workspace.



Flange Generative Design Steps

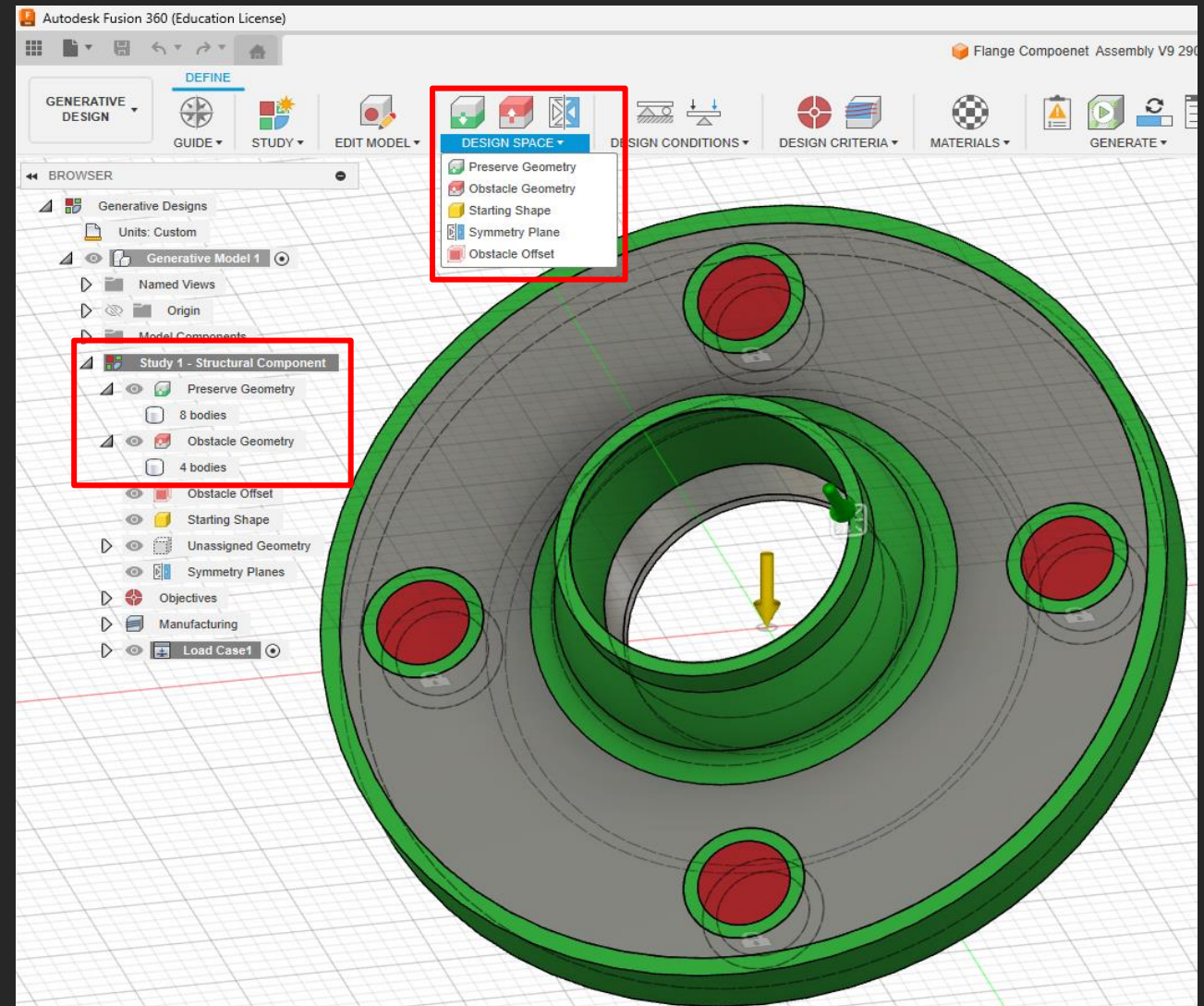
Step 3:

Navigate the Design Space menu to assign **Preserve Geometry** and **Obstacle Geometry**.

Preserve Geometry – 8 Bodies selected as parts that should not change during generation of outcome.

Obstacle Geometry – 4 Bodies selected as spaces where materials shouldn't be placed during the generation of outcome.

NB: These are the only crucial design space required for this type of component.

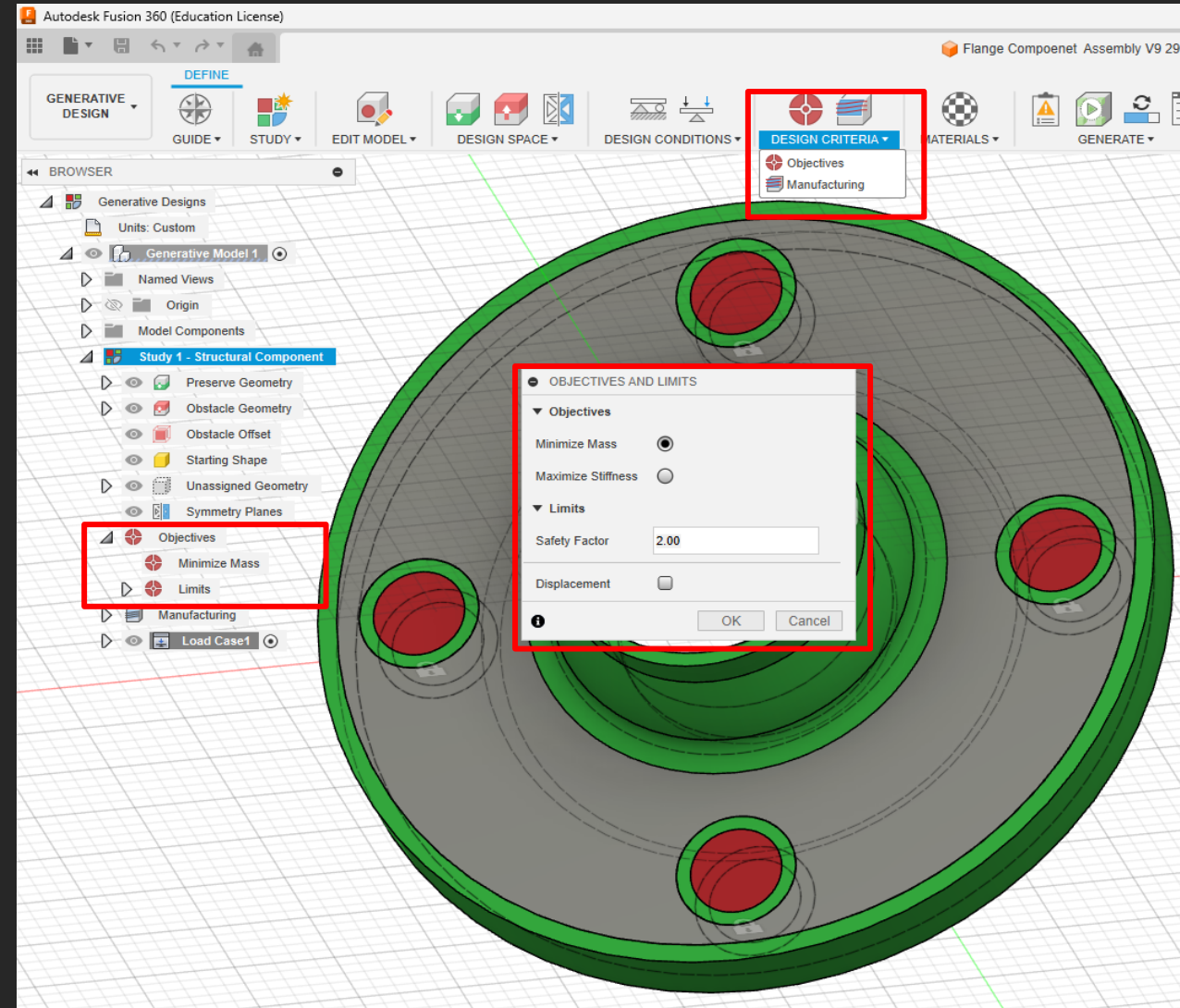


Flange Generative Design Steps

Step 4:

Set **Objective** to **Minimize Mass** and **Limit Safety Factor** to 2.

- With a safety factor of 2, the objective is to minimise mass while ensuring safety.
- Yield strength is vital for ductile materials; exceeding it leads to permanent deformation. For brittle materials, Ultimate Tensile Strength (UTS) is crucial.
- In a flange component, balancing material strength with minimised mass is critical for optimal and safe design.

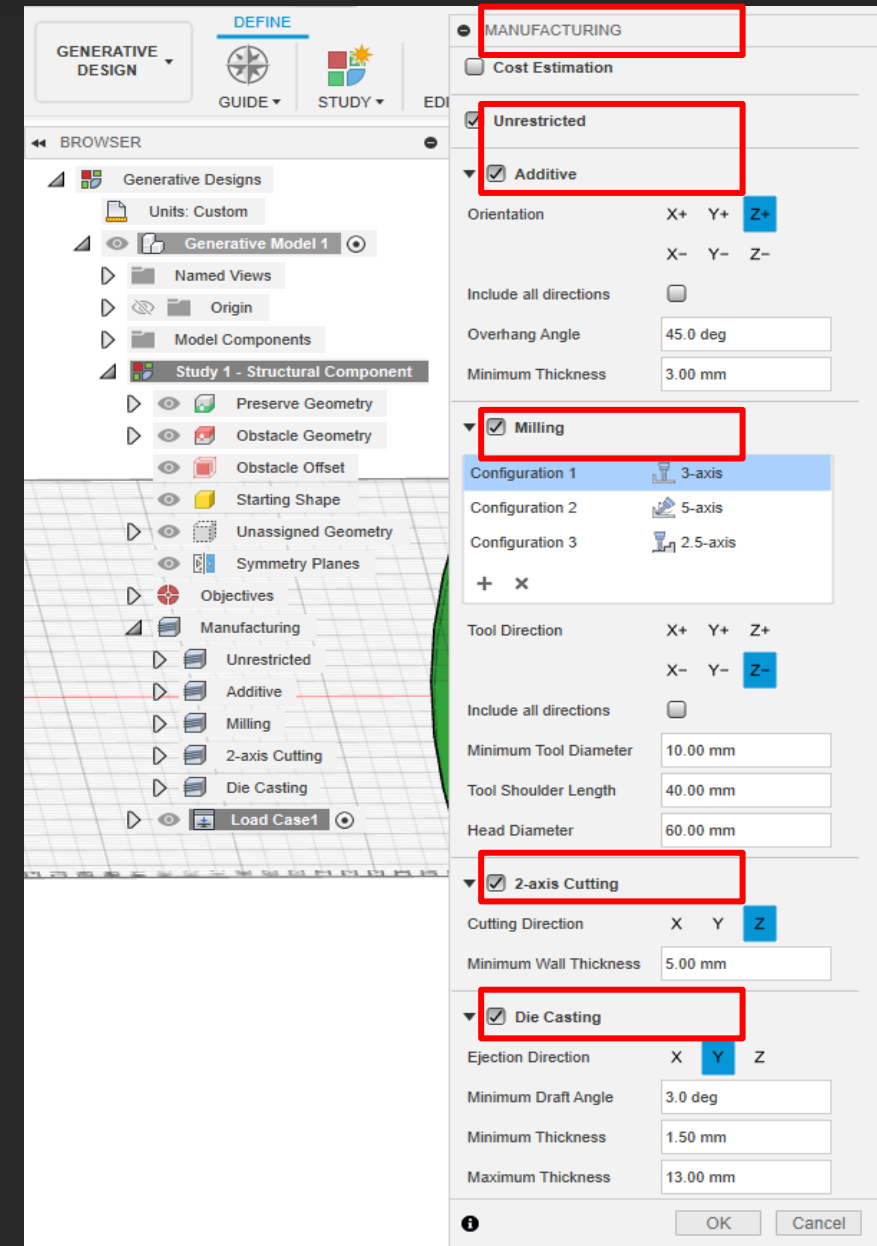


Flange Generative Design Steps

Step 5:

Set **Manufacturing Constraints** for the design process.

- All options including **Additive Manufacture** is selected notwithstanding the size of the flange component.



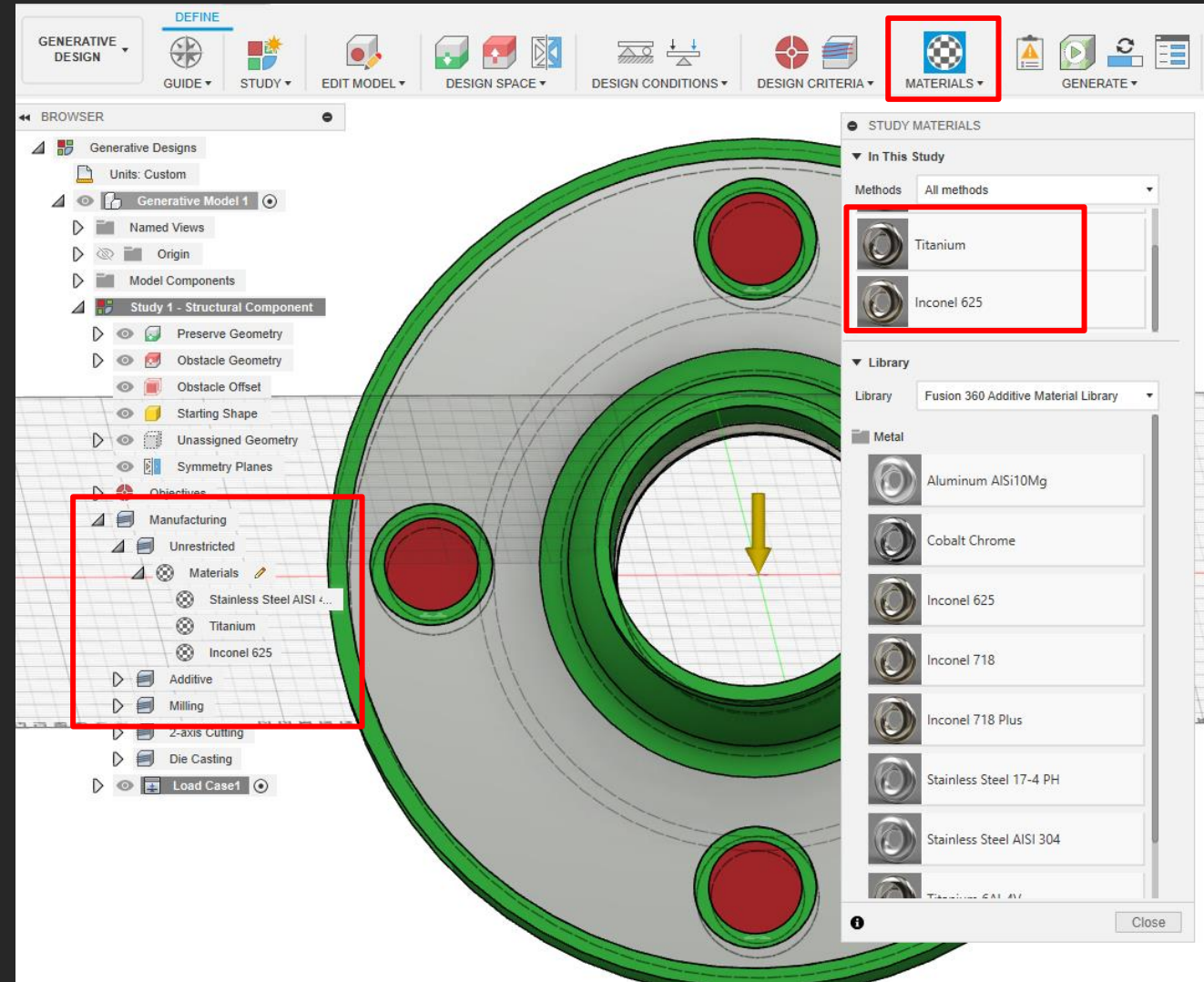
Flange Generative Design Steps

Step 6:

Select **Material** types from library.

- **Titanium, Inconel 625, and Stainless Steel AISI 446** are selected based on desired outcome.

- Materials applied to all manufacturing methods selected.

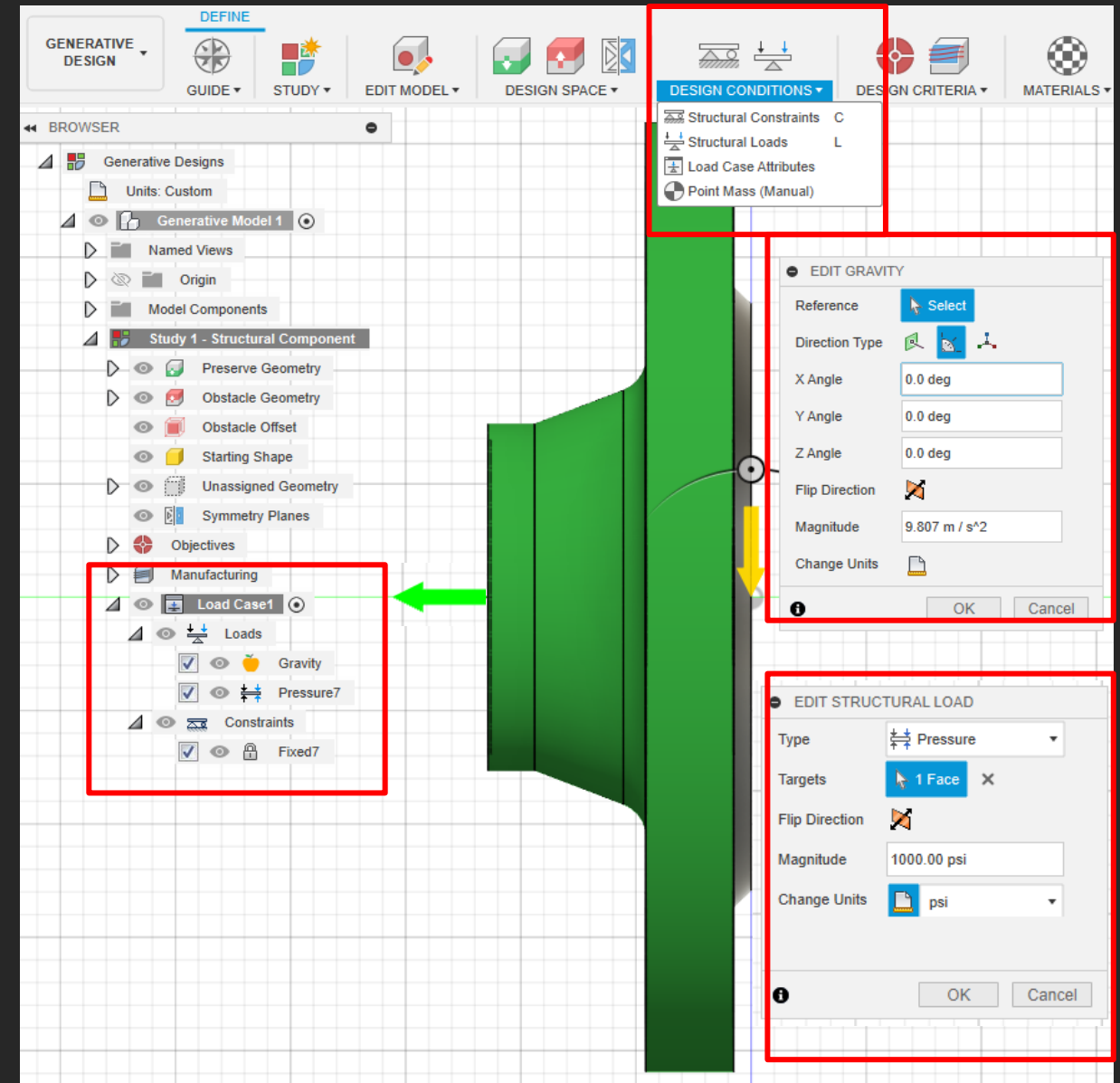


Flange Generative Design Steps

Step 7:

Set Structural Load.

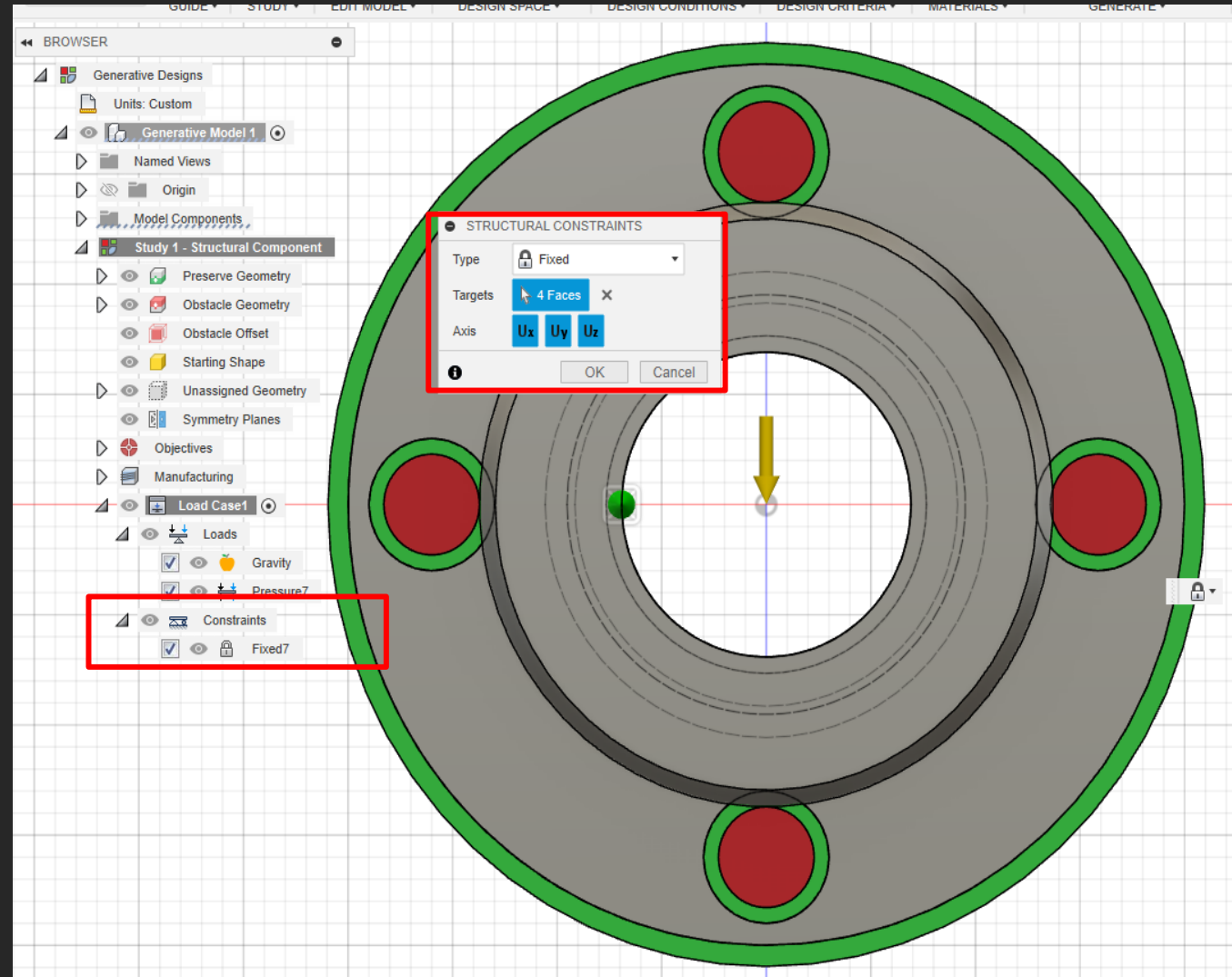
- Gravity Set – **Yellow Arrow**
- Load set as Pressure – 1000 PSI –
Direction Set – **Green Arrow**



Flange Generative Design Steps

Step 8: Set **Structural Constraints**.

- Four Fixed faces assigned to the selected Geometry.

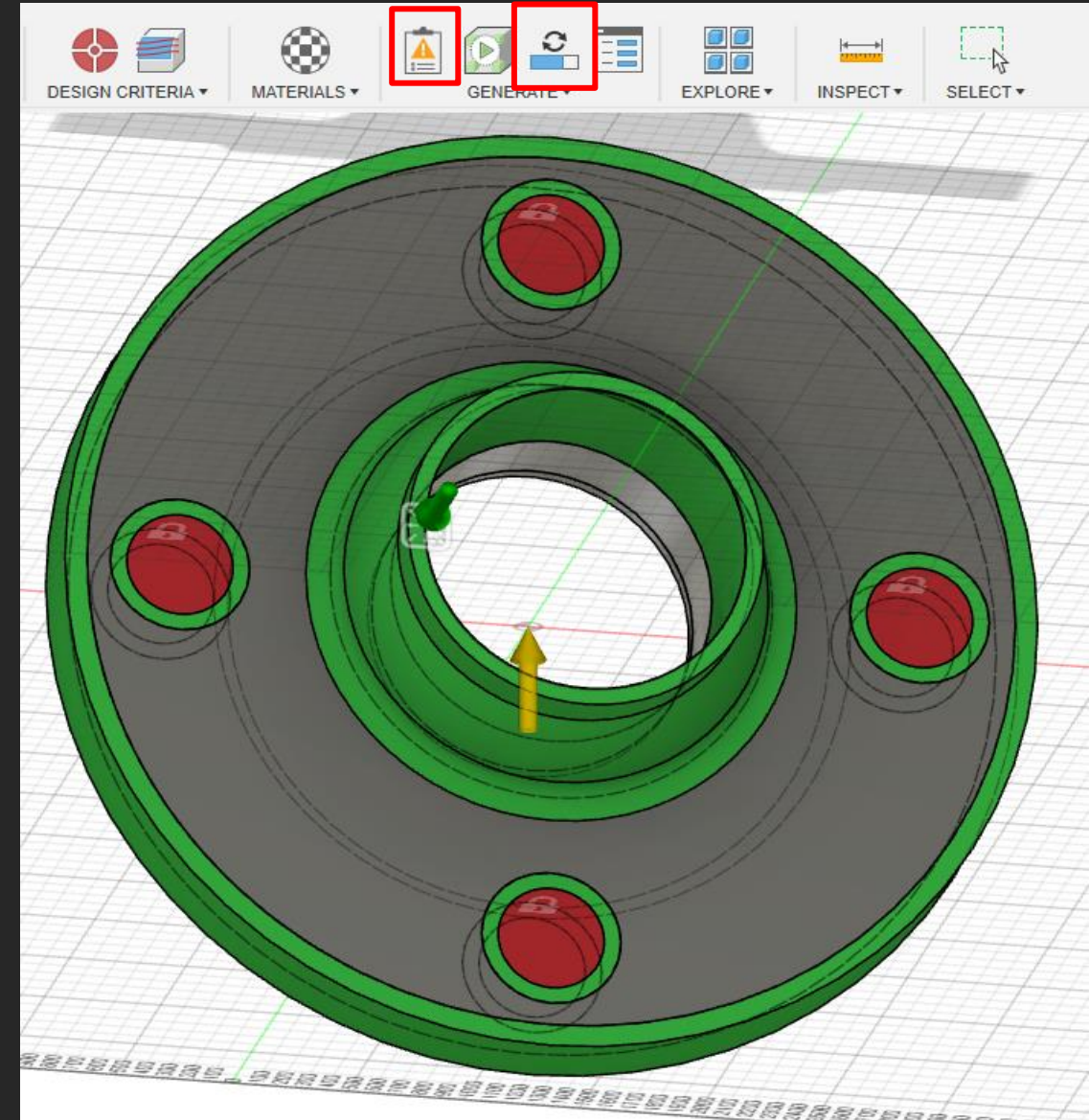


Flange Generative Design Steps

Step 9:

When satisfied with the parameters entered, click **Pre-Check** to ensure setup meets the requirement outcome.

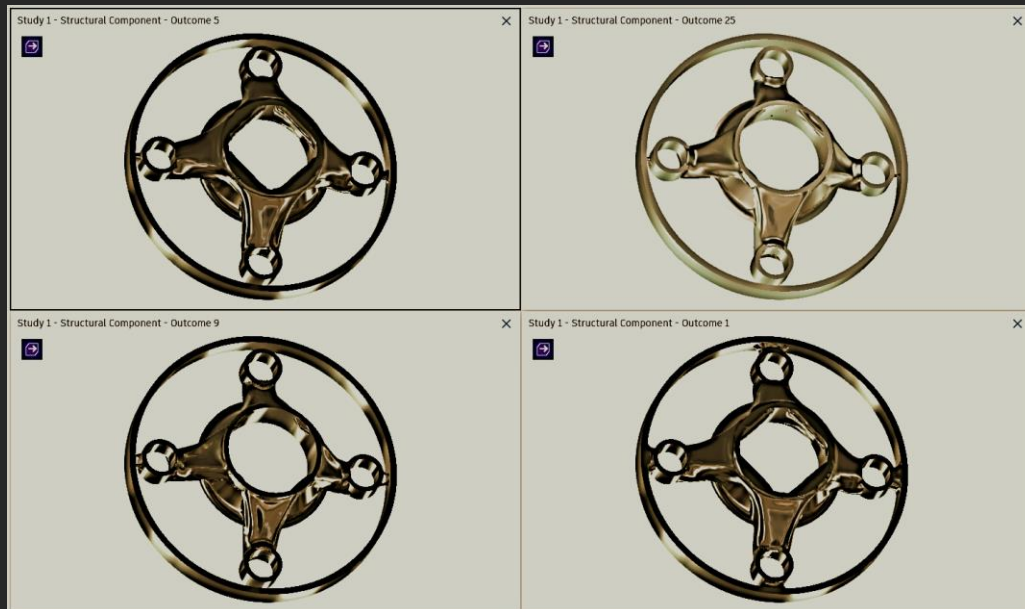
>> Click **Generate** to begin processing of Study.



Outcome Analysis

✓ Recommended outcomes Compare

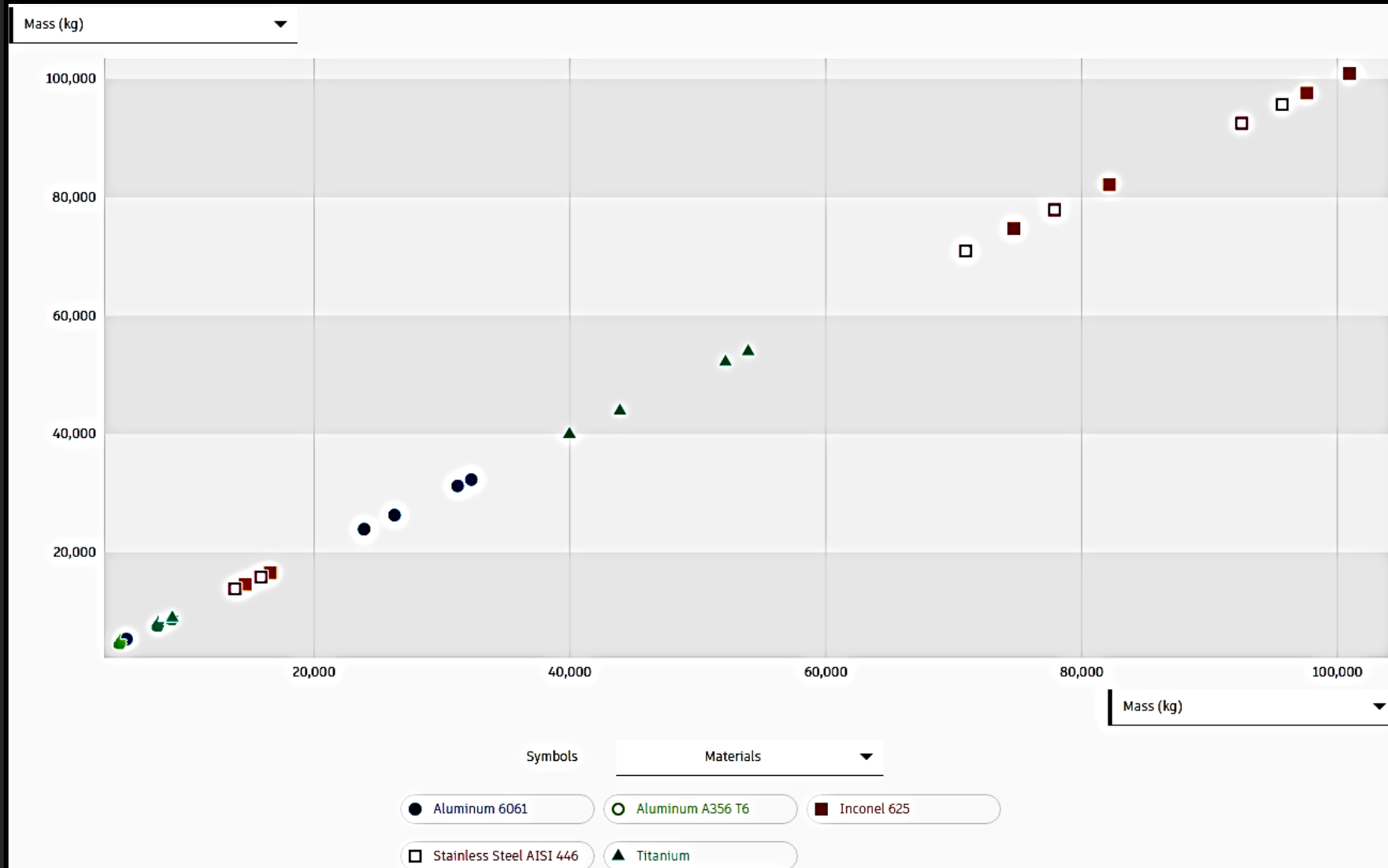
			
Study 1 - Structural ... - Outcome 1 Converged	Study 1 - Structural... - Outcome 5 Converged	Study 1 - Structural... - Outcome 9 Completed	Study 1 - Structur... - Outcome 25 Completed



Out of the 4 recommended Outcomes, 1 and 5 are the only Converged outcomes.

NB: "Converged" status means the algorithm has found a satisfactory solution, while "Completed" status means the algorithm has completed all planned iterations or variations, regardless of whether a satisfactory solution was found.

Outcome Analysis



Mass analysis indicates Aluminium and Titanium as better materials compared to Stainless Steel and Inconel.

Outcome Analysis

Name	Preview Features	Recommendation ↓	Processing status	Generative model	Material	Manufacturing method
 Study 1 - Structural ... - Outcome 25		92.003 %	Completed	Generative Model 1	Aluminum A356 T6	Die casting
 Study 1 - Structural ... - Outcome 9		91.501 %	Completed	Generative Model 1	Titanium	Die casting
 Study 1 - Structural ... - Outcome 5		90.377 %	Converged	Generative Model 1	Titanium	5 axis milling
 Study 1 - Structural ... - Outcome 1		90.31 %	Converged	Generative Model 1	Titanium	Unrestricted
 Study 1 - Structural ... - Outcome 18		88.412 %	Completed	Generative Model 1	Stainless Steel AISI 446	Die casting
 Study 1 - Structural ... - Outcome 34		88.12 %	Completed	Generative Model 1	Inconel 625	Die casting
 Study 1 - Structural ... - Outcome 14		86.185 %	Converged	Generative Model 1	Stainless Steel AISI 446	5 axis milling
 Study 1 - Structural ... - Outcome 10		86.087 %	Converged	Generative Model 1	Stainless Steel AISI 446	Unrestricted
 Study 1 - Structural ... - Outcome 30		85.558 %	Converged	Generative Model 1	Inconel 625	5 axis milling
 Study 1 - Structural ... - Outcome 26		85.356 %	Converged	Generative Model 1	Inconel 625	Unrestricted
 Study 1 - Structural ... - Outcome 20		77.305 %	Completed	Generative Model 1	Aluminum 6061	3 axis milling
 Study 1 - Structural ... - Outcome 22		73.873 %	Converged	Generative Model 1	Aluminum 6061	2.5 axis milling
 Study 1 - Structural ... - Outcome 2		70.219 %	Converged	Generative Model 1	Titanium	Additive
 Study 1 - Structural ... - Outcome 11		65.922 %	Converged	Generative Model 1	Stainless Steel AISI 446	Additive
 Study 1 - Structural ... - Outcome 27		65.2 %	Converged	Generative Model 1	Inconel 625	Additive

❑ **Overall Analysis highlights Outcome 5 as the best outcome.**

❑ **Die Casting method are inconclusive.**

❑ **Additive Manufacturing methods are least recommended due to size of flange.**

Outcome Analysis

Outcome 5 Selection Criteria

- ☐ Orientation – Unrestricted
- ☐ Method – 5 Axis Milling
- ☐ Current Mass – 8,910
- ☐ Previous Mass – 43,618

Total Mass Reduction – **34,708**
while still maintaining Safety
Factor of 2.



Future Trends

Current State	Future Trend
Current weaknesses in generative design and Fusion 360 include algorithm limitations and challenges in handling complex geometries.	Future trends involve AI-driven algorithms for more intelligent designs and improved integration with manufacturing, ensuring seamless transitions from virtual models to physical prototypes. These advancements promise enhanced efficiency and innovation in engineering practices.

Ntintakis and Stavroulakis (2020).

Conclusion

❑ Generative Design Impact:

Crucial in Oil and Gas Manufacturing, optimising efficiency and reducing waste.

❑ Fusion 360 User-Friendly Interface:

Enhances feasibility and quick optimisation for simple designs.

❑ Complex Geometries Challenge:

Scaling time significantly increases for intricate designs in the industry.

Reference

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Q&A

