

## Fusion länk. (VG)

Variant A - <https://a360.co/3uRLoWT>Variant B - <https://a360.co/3fhH50i>Variant C - <https://a360.co/3w9TLgG>

## Foto på er konstruktion. (VG)

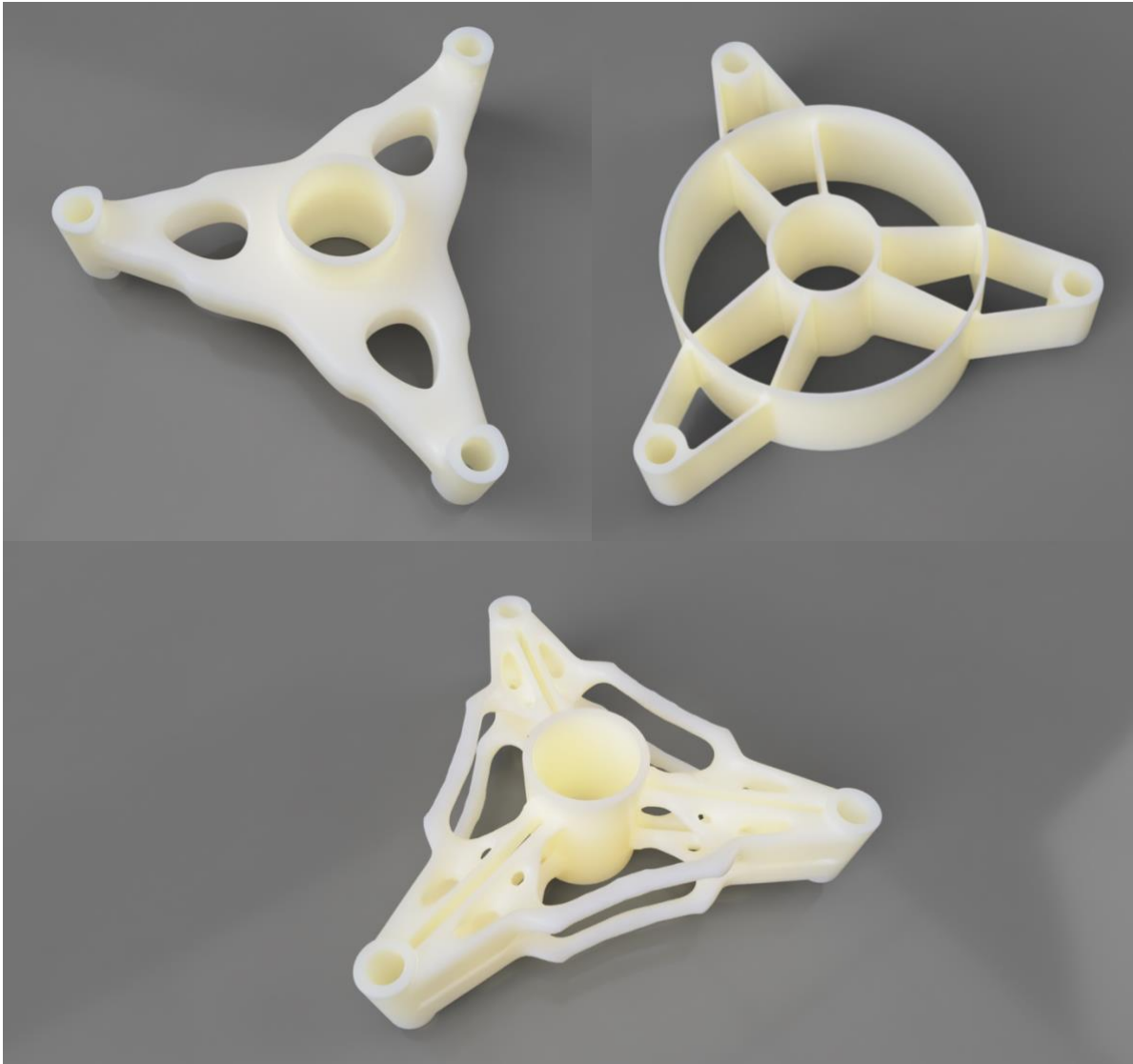


Fig 1 - Three variants modelled after topology optimization in Autodesk Fusion 360 and Altair Inspire. Own Work. Rendered as ABS in Autodesk Fusion 360.

## Topologioptimizing (VG)

Topology optimization takes a series of steps from original shape to optimized result. Either in Altair inspire or Autodesk Fusion 360, the programs have a very straightforward workflow already laid out as a linear progression. (fig 2) It could be an important step now to understand the symmetry of our model and slice it up along the lines of symmetry to reduce the amount of computation required. In our case the spindelled might be a rotating object and symmetry will allow for balance to be built into the final result.

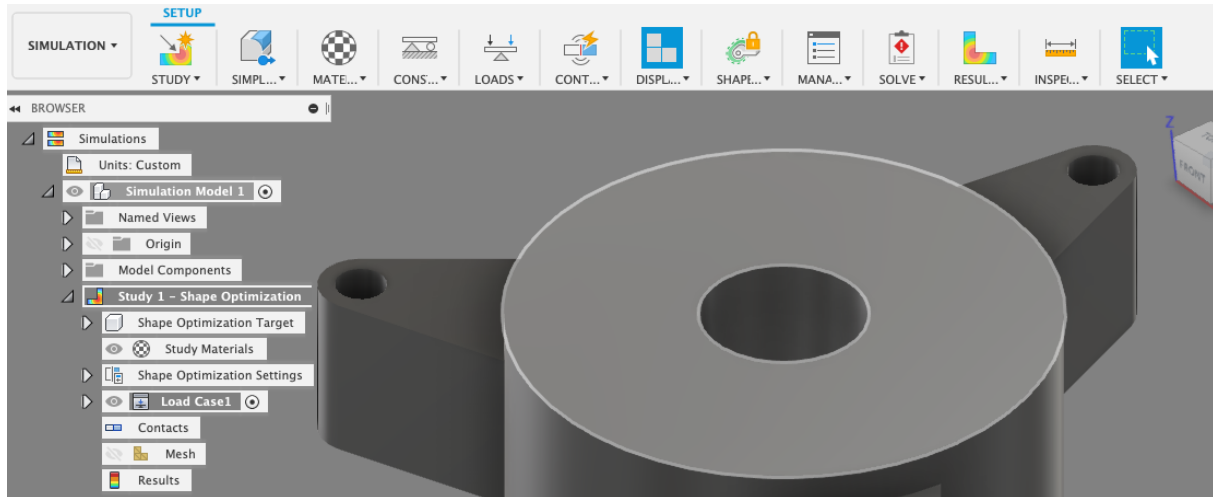


Fig 2 - The simulation workflow as a linear progression is read from left to right in the toolbar in Fusion 360. Screenshot of Autodesk Fusion 360 simulation / mass optimization workspace.

Steps for a successful topology optimization are as follows:

1. Simplify the model. Remove any unnecessary fillets, curves, or other specific features that may not really matter for a general optimization.
2. Add constraints. It is important to understand the load cases on the model to properly add constraints. Sometimes the constraints and loads could be switched to simplify the computation.
3. Add loads. In our case a load moment of 30 Nmm is applied to each small hole in the arm.
4. Preserve regions. Some parts of the model are important to keep as designed, like screw bosses and the center axel hole, so these regions are selected and preserved. In Altair Inspire, this is accomplished by dividing the model and selecting a design space and non-design space options.
5. Get results and convert to CAD. Results are not a finished model. They must be either saved as a mesh and converted to a solid, or a design technique like t-splines in Fusion 360 or polynurbs in Altair inspire can be used to create a useable and editable CAD model.

## Polynurbs/ T-splines (VG)

Polynurbs in Inspire have proven much easier to navigate and use than t-splines in Fusion. The reason I did not use polynurbs for this assignment was twofold. I simply happen to do most of my work in Fusion. I am working on MacOS and Inspire does not support the operating system so I am forced to boot back and forth between MS Windows and MacOS when working in Inspire and Fusion 360.

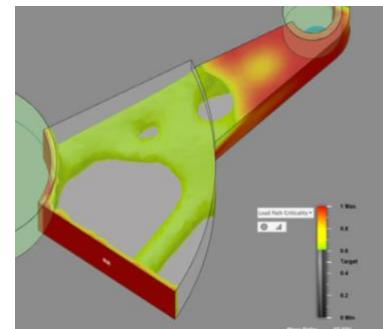


Fig 3 - Intricate form, difficult to t-spline.

I need to improve my skillset working with t-splines. I began working with t-splines to fill in the shapes, but with such a complex mesh I was unable to connect the lofts in what I considered a satisfactory result.

## CAD design av färdig modell (VG)

The final versions of variants A and C were heavily CAD modelled and easily adapted. This is due to the use of simple techniques. Variant A can be seen in figure 4. It is often simpler to work with symmetrical thinking. This way one section can be modelled and simply patterned in the end which can save time because of the reduction in modelling steps.

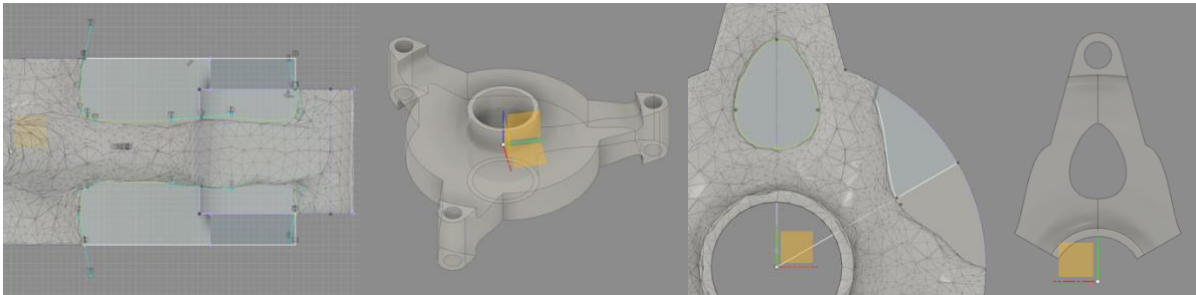


Fig 4 - Steps taken to produce the CAD model from optimized mesh on Variant A. a.) Spline b.) Revolve c.) Extrude cut. Final pattern and fillets can be seen in fig 1.

## Designprocessen i ovanstående moment.

The goal is to redesign the spindelled for this task. We want to minimize mass while maintaining stiffness. In this case we must take into consideration all features that must be present and the forces that will be applied.

### Requirements

- Reduce weight
- Mounted with large hole on an axel.
- Torque of 30 N mm at every arm at hole.

### Design Variants

Three major variants were created and tested in Fusion 360 and a fourth was topology optimized within Altair Inspire for comparison.

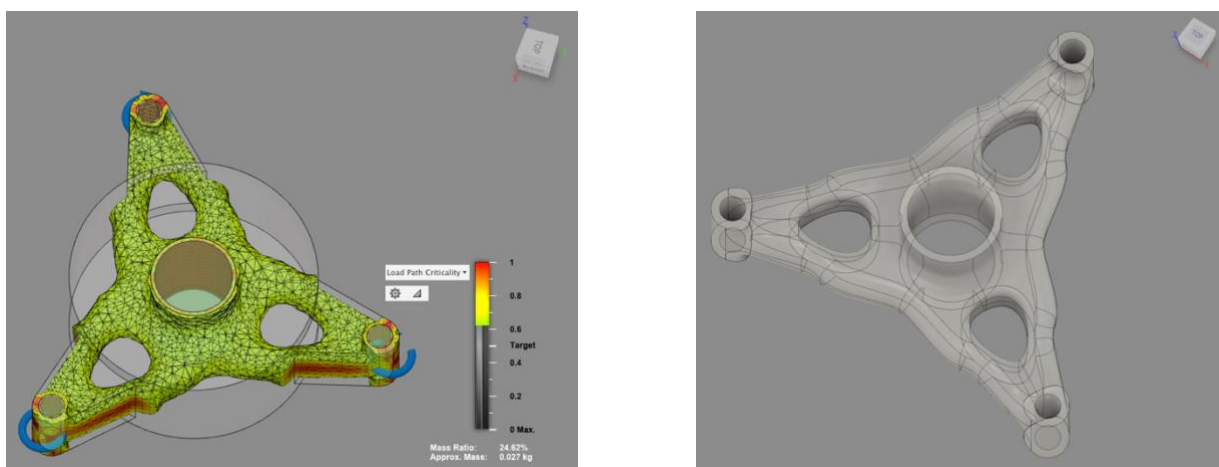


Fig 5 - Variant A. Left, Topology optimized using Fusion 360. Right, finished model ready for static stress analysis. Own work.

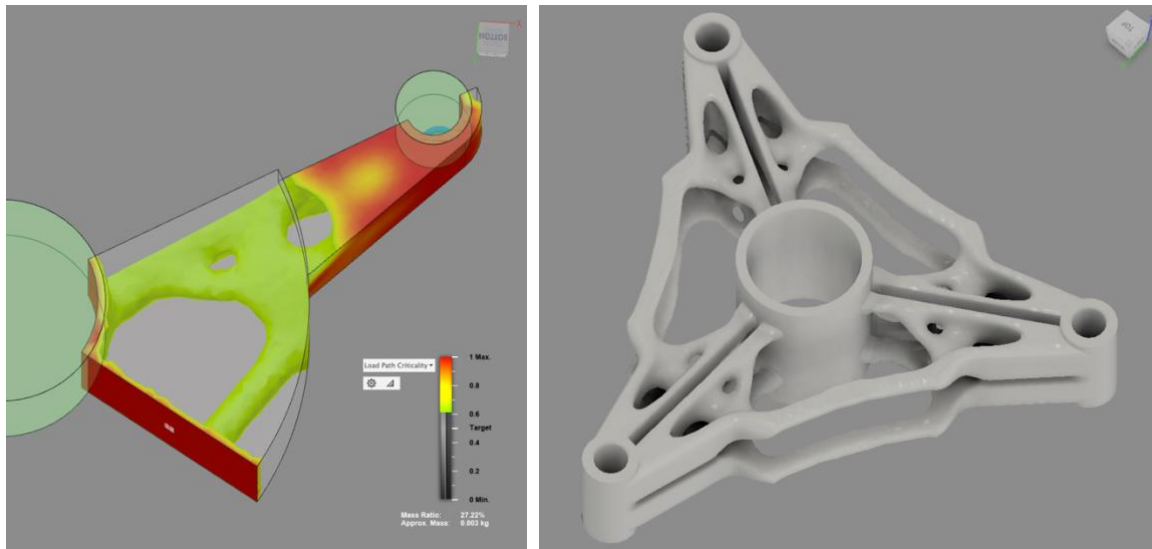


Fig 6 – Variant B. Left, Topology optimized using Fusion 360. Right, finished model ready for static stress analysis. Own Work.

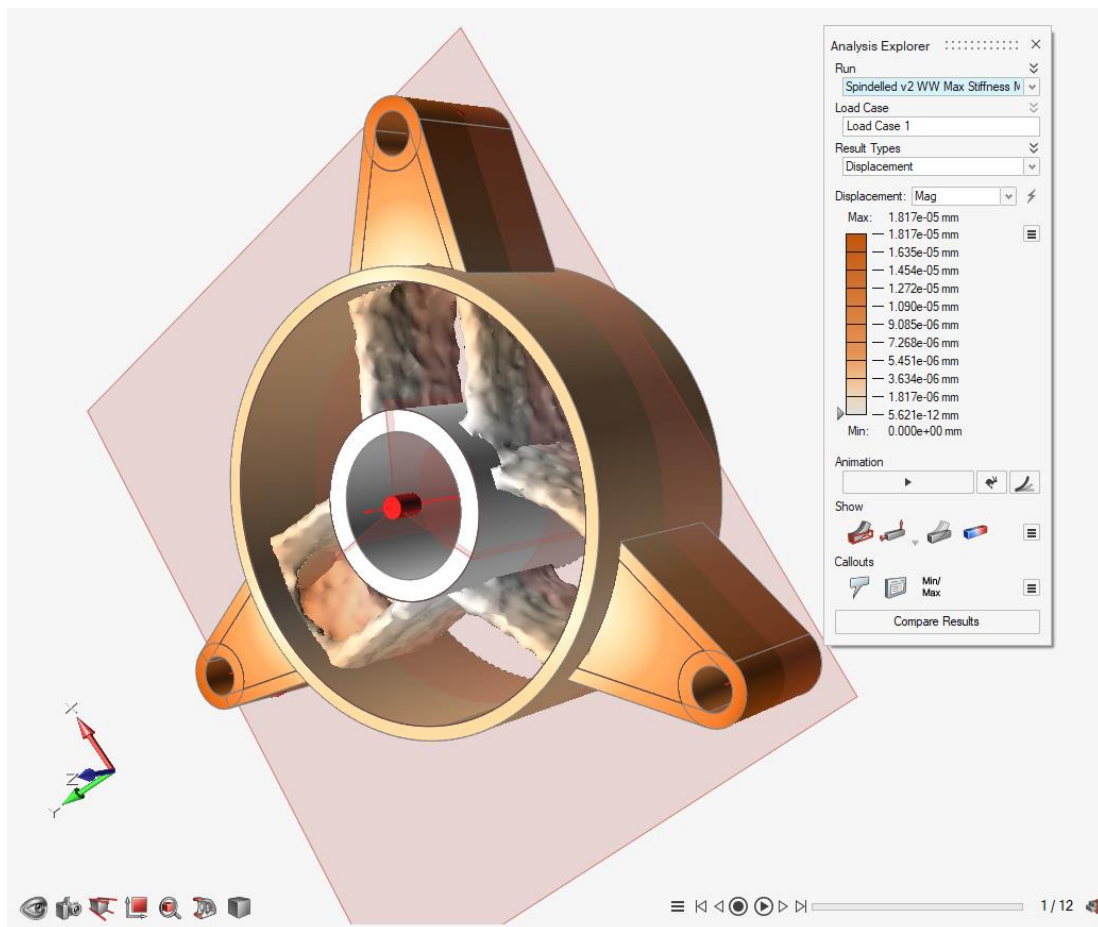


Fig 7 - Topology optimization example as created in Altair inspire. Own work.

## Chosen Variant

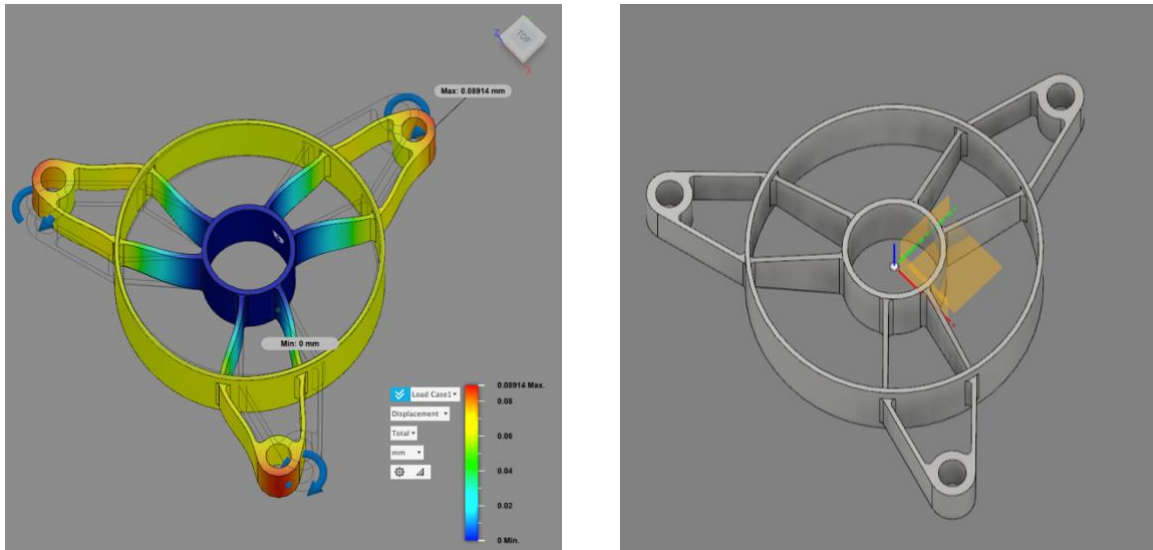


Fig 8 - Chosen variant. Note the simulations show that Variant C uses the least material while maintaining good structural rigidity and minimal deflection. Deflection has been exaggerated for visualization. Own work. Captured from Fusion 360.

## Considerations

Below are the volumes of the three design variants. It is worth noting that after variant A and B topology optimization and CAD modelling it was the simpler variant C that has the least volume while still maintaining stiffness and strength well above the yield threshold of the material. This is shown in the simulations.

Original volume:  $1.048\text{E}+05 \text{ mm}^3$

Variant A volume:  $2.874\text{E}+04 \text{ mm}^3$

Variant B volume:  $2.257\text{E}+04 \text{ mm}^3$

Variant C volume:  $1.723\text{E}+04 \text{ mm}^3$

Furthermore, this model will be the cleanest to print with FDM requiring the least amount of support and leveraging the strength in the XY printing direction.

Simulations on variant A and B CAD models have shown that the topology optimized variants are too strong, over 15 times stronger than the safe working yield of the model when ABS material is chosen.

## Material

PLA will be the material used in printing the spindelled for a future assignment. For the purpose of our evaluation we choose ABS as it is already present in Fusion 360's materials database and is also a typical material used in FDM.

## Printing via FDM

The final design is meant for us to print via FDM technology. This means that we must consider the quirks of the FDM printing technique throughout our design process. FDM is typically stronger in the XY plane than the Z direction due to the printing path being relatively continuous in the XY and then stepping up to produce the next XY layer in the Z.

We could consider support requirement during printing and design to minimize the need for support material during printing if possible.

Post processing is another consideration. It will be important for us to try to design away the need for any post processing or other handling after the print is complete. This will save labor and time making the whole process more efficient.

## Varför Topologioptimera? (VG)

Topology optimization is a powerful tool for visualizing potential load path stresses in a model. Unfortunately, topology optimization does not take into account any load stress magnitude and will give similar results when applying 0.5 Nmm or 500 Nm of force in the simulation. Therefore, it is up to the designer to utilize common sense and run proper simulations on the next design iterations after optimization. Having the tool seems to be an overall benefit for quickly realizing designs, but it is very important to apply loads accurately for best results.

## Övriga egna reflektioner

It is very fun to play with topology optimization. I very much want to try my hand at generative design. It is very clear that topology optimization and generative design has a home in the world of additive manufacturing. There are definitely some incredible CNC machines out there but the complexity of some of these topology-optimized designs are impossible or at least entirely cost prohibitive to mill out of huge blocks of material. It's clear that FDM is not the optimal method to produce parts with small features like created in topology optimization and lattice structures, but other additive techniques especially the powder bed supportless types are very well suited.

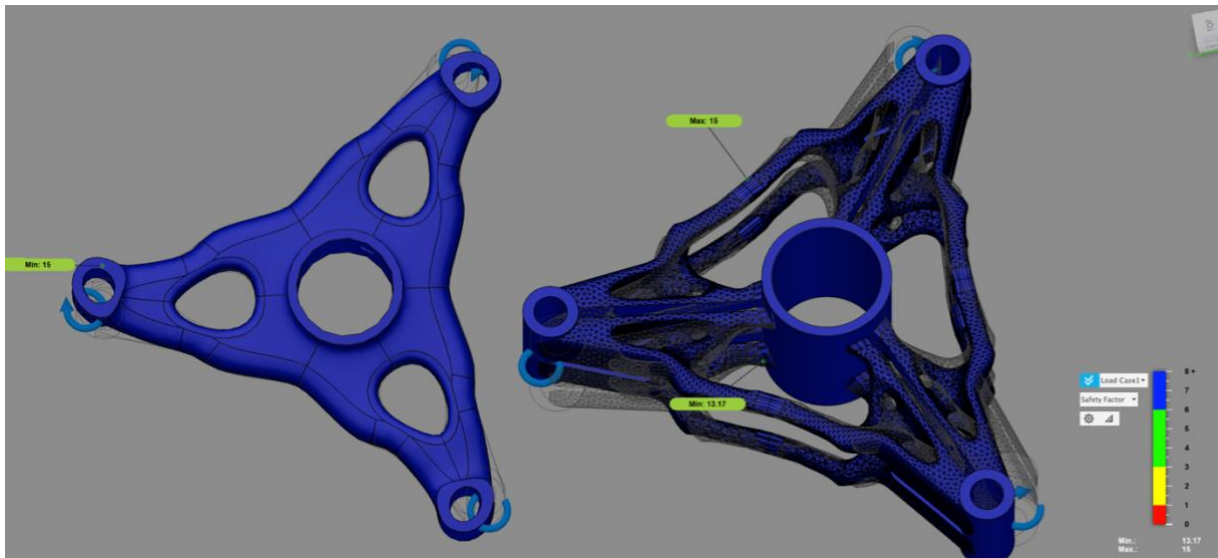


Fig 9 - Static stress analysis of variants A and B in ABS. Note the loads are over 15 times above nominal working yield strength of ABS meaning these designs could be further optimized. Own work. Captured in Fusion 360 simulation workspace.