

ACM Assignment 2 - Complete

by Nia Catrin David

Submission date: 26-Jan-2020 09:15PM (UTC+0000)

Submission ID: 119133286

File name: 6173_Nia_Catrin_David_ACM_Assignment_2_-_Complete_231305_1015136767.docx (4.54M)

Word count: 4305

Character count: 23352

Student Number: P151615

January 2020

Advanced Computational Methods

ULA Rocket Hardware Design

Module Code: M6X00408



Figure 1 - Atlas V Rocket (United Launch Alliance, 2010).

Nia David (P151615)

1. Executive Summary

The report optimised the design of a support bracket used for an Atlas V rocket. The bracket has the purpose of securing the engineering work platforms and therefore the redesigned bracket also needs to be capable of withstanding the functional requirements. The design brief specified that the bracket must be manufactured using Ultem 9085, and will be manufactured via the method of 3D printing to widen the design possibilities.

The software package named Design Studio aided the design improvements by ensuring the conceptual designs were developed logically by focusing on the inputted topology objectives. The software supported the construction of a more complex design that otherwise probably would not have been easily imagined.

An optimised bracket was produced however, it met all but one design requirement; the minimum edge distance around two bolt holes was lower than required. More work will need to be completed to determine a solution. Further design and analysis improvements have been identified and discussed within the report to further correct and optimise the part.



2. Table of Contents

1. Executive Summary	2
2. Table of Contents	3
2.1. Table of Figures	4
2.2. Table of Tables	5
2.3. Table of Equations	5
3. Introduction	6
4.1. Report Scope	6
4.2. Function and Load Cases of Part	6
5. Conceptual Study	7
5.1. SolidWorks Mesh	7
5.1.1. Determined Mesh Size	7
5.2. Design Studio - Analysis Inputs	8
5.2.1. Material Selection	8
5.2.2. Grid Component Sets	9
5.2.3. Static Loads and Load Cases	10
5.3. Design Studio – Topology Inputs	11
5.3.1. Topology Regions	11
5.3.2. Topology Objectives	12
5.3.3. Topology Constraints	12
6. Analysis	13
6.1. Single Analysis	13
6.1.1. Displacement	13
6.1.2. Solid Stress	14
6.1.3. Solid Strain	15
6.2. Suggested Design Changes	16
6.3. Optimisation Results	17
6.4. Improving Optimisation Results	20
6.5. Critical Appraisal	22
7. Conclusion	23
8. References	24

2.1. Table of Figures

Figure 1 - Atlas V Rocket (United Launch Alliance, 2010).....	1
Figure 2 - Atlas V Rocket Diagram showing Bracket Location (UWTSD ACM Module, 2019).....	6
Figure 3 - Image Showing Measurement of Thinnest Part of Bracket (Rossiter, 2020).....	7
Figure 4 - Design Studio Material Inputted Directly from Table 2 (Rossiter, 2020).....	8
Figure 5 - Close Up of Envelope Drawing showing 'Hole Pattern D' (UWTSD ACM Module, 2019).	9
Figure 6 - Grid-Component Sets (Rossiter, 2020)	9
Figure 7 - Grid-Component Sets (Rossiter, 2020)	9
Figure 8 - Close Up of Envelope Drawing showing 'Hole Pattern E' (Rossiter, 2020).....	10
Figure 9 - Static Load UDL All Grids on Part Face (Rossiter, 2020)	10
Figure 10 - Static Load UDL Selected Grids on Part Face (Rossiter, 2020)	10
Figure 11 – Topology Region, Initial Mass Fraction (Rossiter, 2020).	11
Figure 12 - Design Region Constraints (Rossiter, 2020).	11
Figure 13 – Minimising Strain Energy (Rossiter, 2020).	12
Figure 14 – Material Reduction (Rossiter, 2020).	12
Figure 15 - Single Analysis Displacement Results (Rossiter, 2020).	13
Figure 16 – High Displacement (Rossiter, 2020).	13
Figure 17 – Low Displacement (Rossiter, 2020).	13
Figure 18 - Single Analysis Stress Results (Rossiter, 2020).	14
Figure 19 -Maximum Stress (Rossiter, 2020).	14
Figure 20 – Minimum Stress (Rossiter, 2020).	14
Figure 21 - Single Analysis Strain Results (Rossiter, 2020).	15
Figure 22 – Maximum Strain (Rossiter, 2020).	15
Figure 23 – Minimum Strain (Rossiter, 2020).	15
Figure 24 – Front Image of Stresses Experienced on Envelope (Rossiter, 2020).	16
Figure 25 - Back Image of Stresses Experienced on Envelope (Rossiter, 2020).	16
Figure 26 – Non-Smeared Optimised Bracket with Original Topology Region (Rossiter, 2020).	17
Figure 27 - High Stress Nodes shown at Boundary Conditions (Rossiter, 2020).	17
Figure 28 - Optimised Part Properties from SolidWorks (Rossiter, 2020).	18
Figure 29 - Minimum Wall Thickness Value from SolidWorks (Rossiter, 2020).	18
Figure 30 – SolidWorks Image Showing Minimum Hole Edge Distance Around Lower Holes (Rossiter, 2020).	19
Figure 31 - Bolt Hole Surrounding Distance Measurement Measured within SolidWorks (Rossiter, 2020).	19
Figure 32 - Design Studio Image showing Wasted Material Remaining on Optimised Part (Rossiter, 2020).	20
Figure 33 – GrabCAD ULA Bracket Design (United Launch Alliance, 2016).	20
Figure 34 - GrabCAD ULA Bracket Design (United Launch Alliance, 2016).	21
Figure 35 - Reducing Time for a Design Process (UWTSD ACM Module, 2019).	21
Figure 36 – Image showing Grid Elements within Optimised Bracket Part (Rossiter, 2020).	22
Figure 37 – Image showing Alternative Improved Method to Conduct Thickness Analysis (Rossiter, 2020).	22

Student Number: P151615

2.2. Table of Tables

Table 1 - Design Requirements (UWTSD ACM Module, 2019).	6
Table 2 – Ultem 9085 Material Properties (UWTSD ACM Module, 2019) and (STRATASYS, 2017).	8

2.3. Table of Equations

Equation 1 - Mesh Size Calculation (Rossiter, 2020).....	7
Equation 2 - UDL Grid Load Calculation (Rossiter, 2020).....	11
Equation 3 - Minimum Size Equation (Rossiter, 2020).	11
Equation 4 – Total Mass of Optimised Bracket (Rossiter, 2020).	18

3. Introduction

4.1. Report Scope



The scope of the report is to optimise the design of a support bracket used on an Atlas V rocket. The bracket location is shown within Figure 2 and will remain with the rocket during flight. Launch vehicle weight has a first order effect on the performance of the system, therefore minimising weight of the bracket will dramatically improve the weight to orbit ratio.

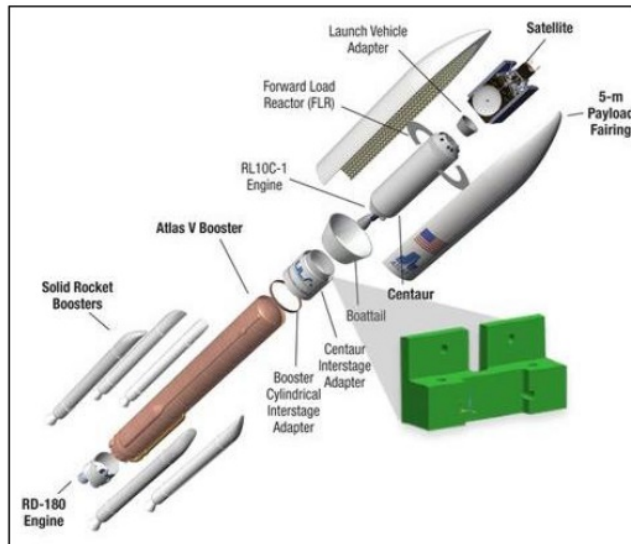


Figure 2 - Atlas V Rocket Diagram showing Bracket Location (UWTSO ACM Module, 2019).

4.2. Function and Load Cases of Part

The bracket has the sole purpose of securing the engineering work platforms used during ground processing. The design brief specified that the Ultimate Load applied to the bracket will be 2668.93N as shown in Table 1. The Ultimate Load value has been calculated by multiplying the average male mass of 89.7kg (U.S. Department of Health & Human Services, 2017) by a safety factor. A relatively large safety factor of 3 was chosen to ensure the platform could accommodate both an engineer and any required equipment too. The total maximum load calculated therefore was 2640N, which is only 28N less than the specified design brief value which verifies the anticipated load is realistic.

1.

Design Requirements: Atlas V Bracket	
Values from Design Brief (UWTSO ACM Module, 2019)	
Property	Conversion
Maximum Part Weight	0.01 Pounds → 0.0454 Kilograms
Minimum Wall Thickness	0.040 Inches → 1.02 Millimetres
Ultimate Load (Due to Work Platform):	600 Pounds → 2668.93 Newtons (Applied Uniformly in the Negative Z Direction)

Table 1 - Design Requirements (UWTSO ACM Module, 2019).

5. Conceptual Study

5.1. SolidWorks Mesh

5.1.1. Determined Mesh Size

A mesh was applied before running the topology study. The meshed part created a pyramid shape along the surface called “elements” and the more elements used, the finer the mesh and therefore the better the model is represented (G.R. Liu, 2003). Unfortunately, the finer the mesh, the larger the run time therefore it is important to determine an appropriate mesh size.

The mesh size will influence the quality of topology studies therefore, it is recommended by SolidWorks Help Forum (SolidWorks Help, 2019) to use “30% of the thinnest dimension of the part”. Figure 3 shows the dimension of the thinnest part of the bracket therefore a draft quality mesh size of 1.2mm was applied as per Equation 1.

$$\begin{aligned} \text{Mesh Size} &= 30\% \text{ of } 3.8\text{mm} \\ \therefore \text{Mesh Size Approximately} &= 1.2\text{mm} \end{aligned}$$

Equation 1 - Mesh Size Calculation (Rossiter, 2020).

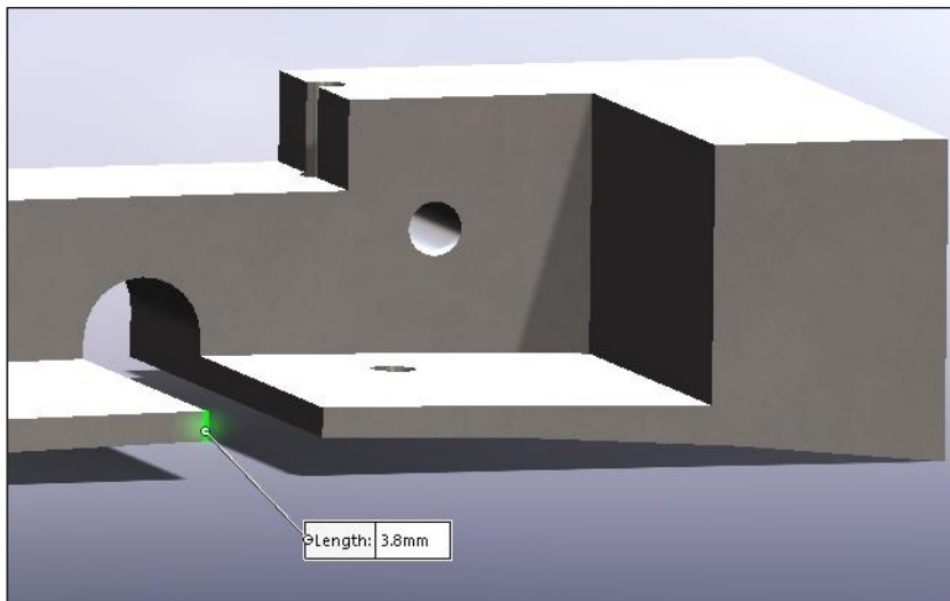


Figure 3 - Image Showing Measurement of Thinnest Part of Bracket (Rossiter, 2020).

5.2. Design Studio - Analysis Inputs

5.2.1. Material Selection

The design brief specified that the bracket must be manufactured using Ultem 9085, and will be manufactured via the method of 3D printing to widen the design possibilities. According to a leading additive manufacturer (Stratasys, 2019), Ultem 9085 resin is a high-performance thermoplastic which features a high strength-to-weight ratio, excellent heat resistance and high impact strength. Stratasys (Stratasys, 2019) continue to explain that the resin also possesses favourable flame, smoke and toxicity characteristics which are critical to aerospace regulations.

Displayed in Table 2 are the material requirements specified from the design brief however, the properties were not all given in SI units therefore conversions were required. Furthermore, the value for Shear Modulus (G) was added to the material specifications from using Ultem 9085 datasheet (STRATASYS, 2017). Without Shear Modulus the conceptual study will not provide a working stress analysis model.

Material Requirements: Ultem 9085	
Values from Design Brief (UWTSD ACM Module, 2019)	
Property	Conversion
Young's Modulus (E)	325 KSI $\rightarrow 2.241E^9 \text{N/m}^2$
Poisson's Ratio (ν)	Conversion Not Required = 0.41 no units
Specific Gravity (Rho)	$1.34 \text{ kg/m}^3 \rightarrow 1340 \text{ g/m}^3$
Material Strength Allowable (ST)	4500 PSI $\rightarrow 3.1026E^7 \text{Pa}$
Values from Material Data Sheet (STRATASYS, 2017)	
Property	Conversion
Shear Modulus (G)	Conversion Not Required = $2.05E^9 \text{Pa}$

Table 2 – Ultem 9085 Material Properties (UWTSD ACM Module, 2019) and (STRATASYS, 2017).

Figure 4 - Design Studio Material Inputted Directly from Table 2 (Rossiter, 2020).

5.2.2. Grid Component Sets

The part will be fastened to the vehicle interface using 4 bolts therefore, fixed geometry in the form of Single-Point Constraint (SPC) was defined around the 4 bolts holes marked as 'Hole Pattern D' in Figure 5. The minimum edge distance surrounding all bolt holes must be double the diameter of the bolt hole, therefore 'Hole Pattern D' must achieve a minimum distance of $\varnothing 0.22$ inches (or $\varnothing 5.6$ mm), therefore totalling a minimum distance of 11.2 mm.

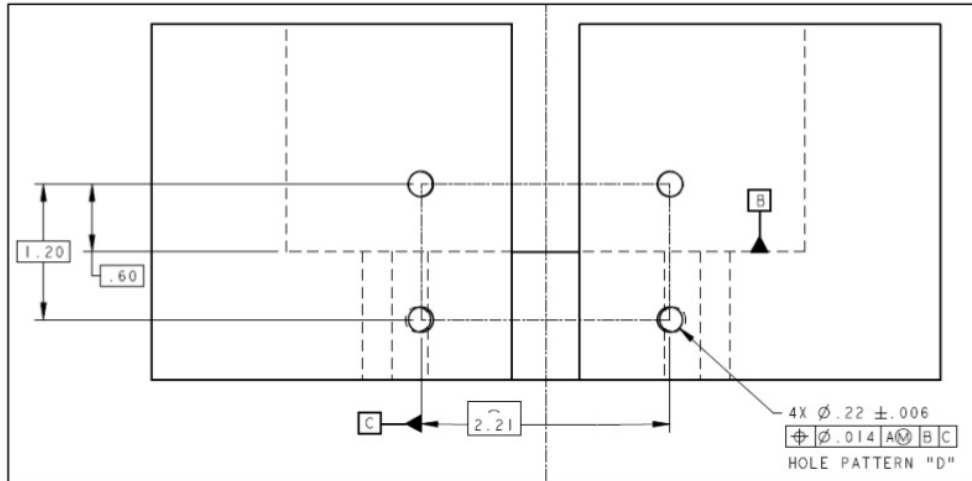


Figure 5 - Close Up of Envelope Drawing showing 'Hole Pattern D' (UWTSD ACM Module, 2019).

Shown in Figure 6 are the nodes around the holes that were selected originally however, shown in Figure 7 is the improved node selection. The improved node selection reduced the depth of selected nodes within the lower, longer clearance holes to match the depths of the upper, shorter clearance holes. It was appropriate to assume the entire depth of each hole was not required as the same stress will be experienced in all four holes therefore there was an opportunity to remove more material.

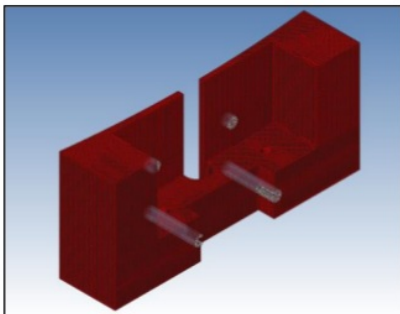


Figure 6 - Grid-Component Sets (Rossiter, 2020)

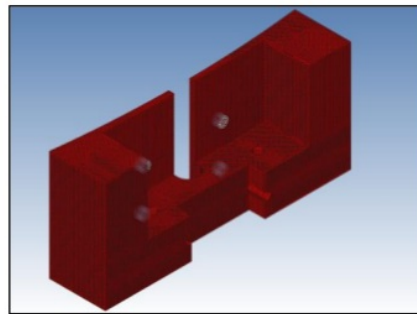


Figure 7 - Grid-Component Sets (Rossiter, 2020)

5.2.3. Static Loads and Load Cases

A static load from the work platform was applied uniformly on the surface located at datum B shown previously in Figure 5 to simulate the engineering work platform attachment. The work platform was fastened using 2 bolts shown as holes marked as Hole Pattern E within Figure 8. The minimum edge distance surrounding all bolt holes must be double the diameter of the bolt hole, therefore 'Hole Pattern E' must achieve a minimum distance of $\varnothing 0.27$ inches (or $\varnothing 6.86$ mm), therefore totalling a minimum distance of 13.72 mm.

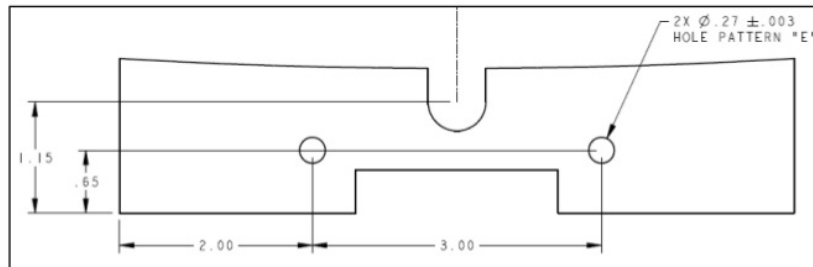


Figure 8 - Close Up of Envelope Drawing showing 'Hole Pattern E' (Rossiter, 2020).

Originally the Design Studio software used all grids on the part face as per Figure 9 however, it was decided to reduce the volume of grids down by removing the outermost grids whilst keeping the central joining path and grids around clearance holes as shown in Figure 10.

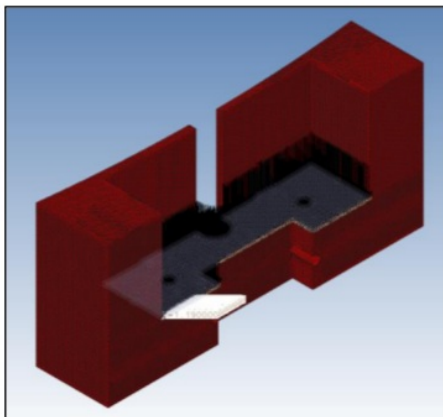


Figure 9 - Static Load UDL All Grids on Part Face (Rossiter, 2020)

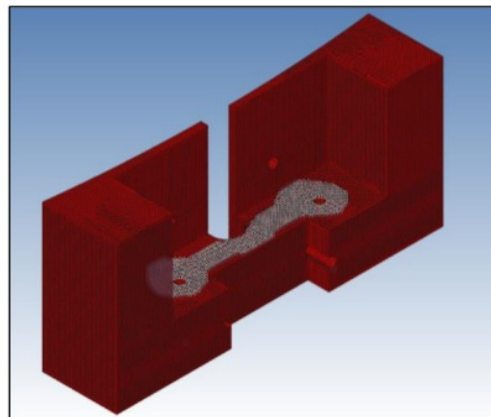


Figure 10 - Static Load UDL Selected Grids on Part Face (Rossiter, 2020)

2. Creating the

Student Number: P151615

The individual load per grid was determined by the magnitude calculation shown within Equation 2. The UDL load was applied uniformly in the negative Z direction as instructed within the Design Requirements hence, $Z = -1$.

$$\begin{aligned} \text{Magnitude} &= \frac{\text{Newtons}}{N^o \text{ of Grid}} \\ \text{Magnitude} &= \frac{2668.93}{1054} \\ \text{Magnitude} &= 1.19\text{N} \end{aligned}$$

Equation 2 - UDL Grid Load Calculation (Rossiter, 2020).

5.3. Design Studio – Topology Inputs

5.3.1. Topology Regions

As shown in Figure 11, the Initial Mass Fraction was set to 0.1 because the design target was to reduce the overall mass of the part to 10% of the original.

Further topology region information was populated into Figure 12. The design requirement was to ensure minimum wall thickness is 1.02mm, or 0.0102m in standard units therefore the minimum thickness was set at 0.01m. The Spread Fraction was set to 0.5 due to the recommended value from university lecturer (UWTSD ACM Module, 2019). The Spread Fraction is representative of the distance between load paths. Lastly, minimum size was calculated by doubling the mesh size as shown in Equation 3;

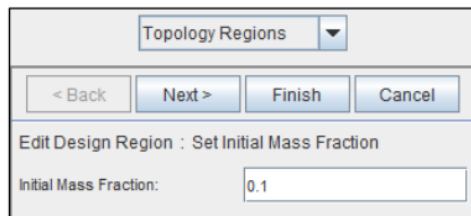


Figure 11 – Topology Region, Initial Mass Fraction (Rossiter, 2020).

$$\begin{aligned} 1.2\text{mm mesh size} \times 2 &= 2.4\text{mm} \\ \therefore &= 0.0024\text{m} \end{aligned}$$

Equation 3 - Minimum Size Equation (Rossiter, 2020).

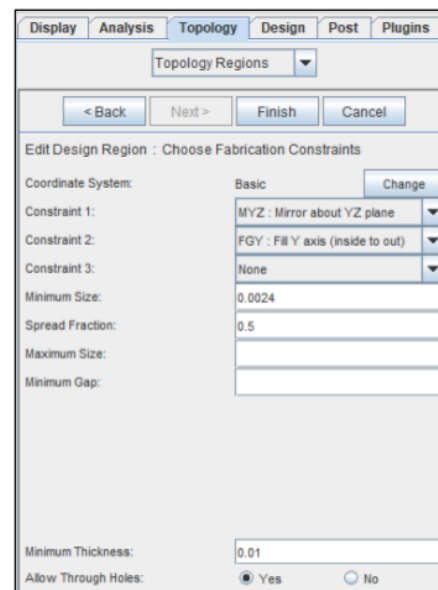


Figure 12 - Design Region Constraints (Rossiter, 2020).

5.3.2. Topology Objectives

Shown in Figure 13, the topology objective weight set to 1.0 to minimise the strain energy on the bracket.

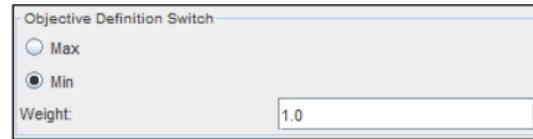


Figure 13 – Minimising Strain Energy (Rossiter, 2020).

5.3.3. Topology Constraints

Shown in Figure 14, the topology constraint upper bound set to 0.1 with the objective of reducing the overall material quantity to 10% of the original bracket.

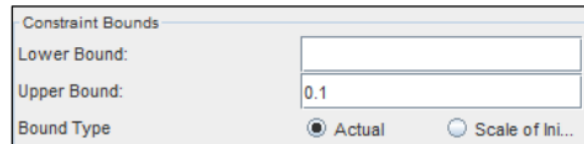


Figure 14 – Material Reduction (Rossiter, 2020).

6. Analysis

6.1. Single Analysis

Before topology optimisation was completed, a single analysis FEA study was run to find the stress, strain and displacement with the end result of highlighting wasted material within the envelop.

6.1.1. Displacement

The displacement study produced a scale factor diagram shown in Figure 15. Both the minimum and maximum results are analysed in Figure 16 and Figure 17.

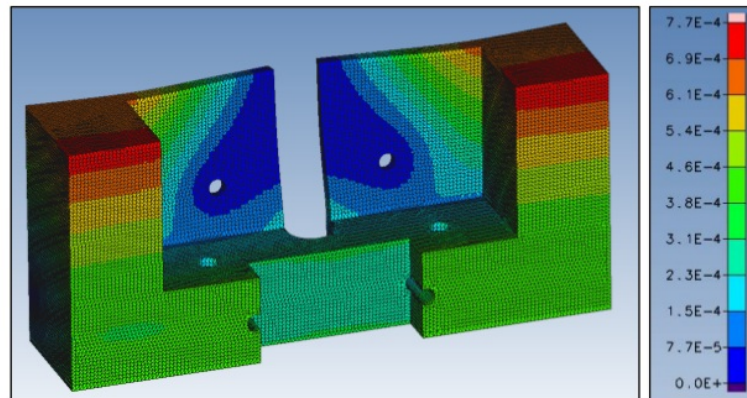


Figure 15 - Single Analysis Displacement Results (Rossiter, 2020).

Maximum displacement occurs where shown in red within Figure 16 as it is the furthest points away from the fixing holes therefore is least supported.

$$\text{Scale Value} = 7.7E^{-4}$$

$$\therefore \text{Maximum Displacement} = 0.77\text{mm}$$

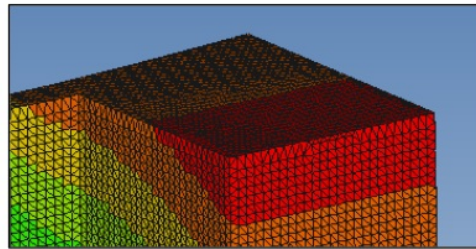


Figure 16 – High Displacement (Rossiter, 2020).

Minimum displacement occurs where shown in blue within Figure 17 as it is the closest points to the fixing holes therefore is most supported.

$$\text{Scale Value} = 7.7E^{-5}$$

$$\therefore \text{Minimum Displacement} = 0.077\text{mm}$$

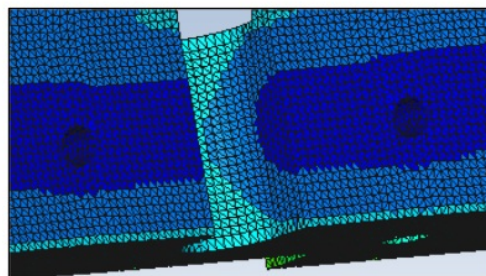


Figure 17 – Low Displacement (Rossiter, 2020).

6.1.2. Solid Stress

The stress study produced a scale factor diagram shown in Figure 18. Both the minimum and maximum results are analysed in Figure 19 and Figure 20. The maximum value of stress for the single analysis study is 10.2MPa, however the maximum allowable stress for this specific material is 31MPa therefore the non-optimised part will pass.

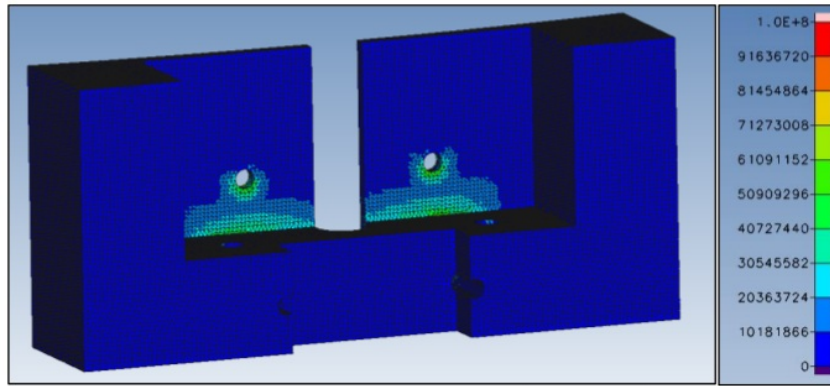


Figure 18 - Single Analysis Stress Results (Rossiter, 2020).

Maximum stress occurs where shown in red within Figure 19.

$$\text{Scale Value} = 1.02E^8$$

$$\therefore \text{Maximum Stress} = 10.2\text{MPa}$$

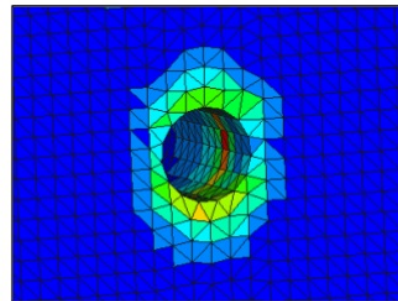


Figure 19 -Maximum Stress (Rossiter, 2020).

Minimum stress occurs where shown in blue within Figure 20.

$$\text{Scale Value} = 1.02E^7$$

$$\therefore \text{Minimum Stress} = 1.02\text{MPa}$$

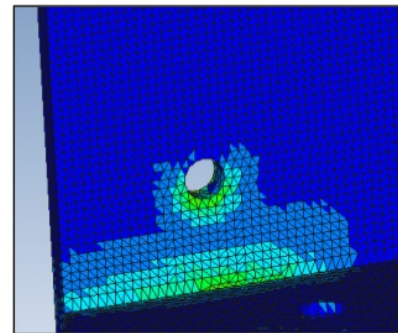


Figure 20 – Minimum Stress (Rossiter, 2020).

6.1.3. Solid Strain

The strain study produced a scale factor diagram shown in Figure 21. Both the minimum and maximum results are analysed in Figure 22 and Figure 23.

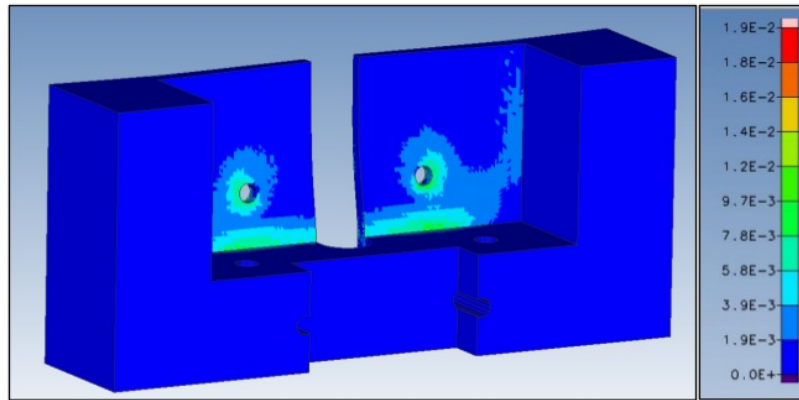


Figure 21 - Single Analysis Strain Results (Rossiter, 2020).

Maximum strain occurs where shown in red and orange within Figure 22.

$$\text{Scale Value} = 1.95E^{-2}$$



$$\therefore \text{Maximum Strain} = 0.0195 \text{ no units}$$

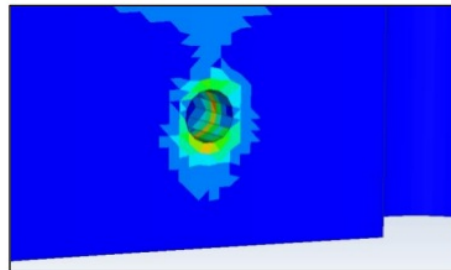


Figure 22 – Maximum Strain (Rossiter, 2020).

Minimum strain occurs where shown in blue within Figure 23.

$$\text{Scale Value} = 1.95E^{-3}$$

$$\therefore \text{Minimum Strain} = 0.00195 \text{ no units}$$

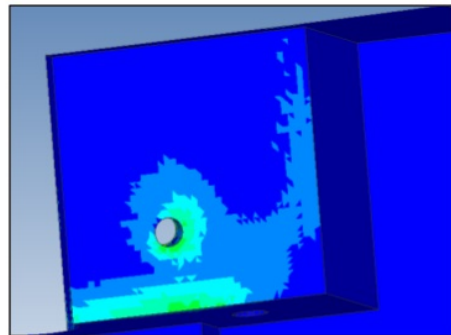


Figure 23 – Minimum Strain (Rossiter, 2020).

6.2. Suggested Design Changes

The single analysis results shown in Figures 24 and 25 influenced the envelop design resulting in removed wasted material which added no mechanical strength to the bracket.

- Areas shown in blue represented the guided material to be removed as it does not experience stress therefore added no mechanical value.
- Areas shown in orange, yellow and green represented nice-to-have areas which added support to the bracket but could potentially be removed or reduced with further analysis.
- Areas shown in red were critical to the component design as this is where most stress and strain is experienced.

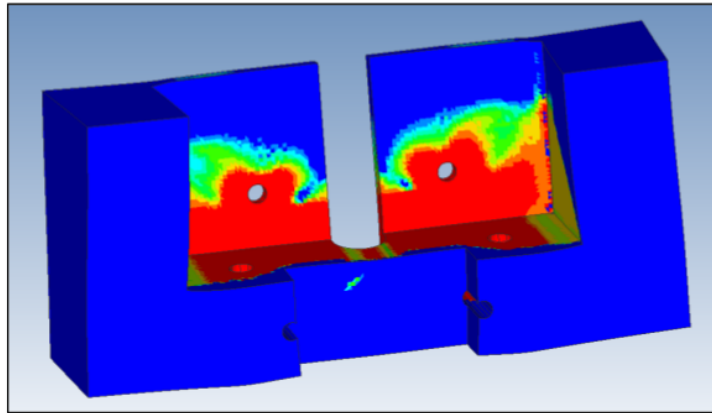


Figure 24 – Front Image of Stresses Experienced on Envelope (Rossiter, 2020).

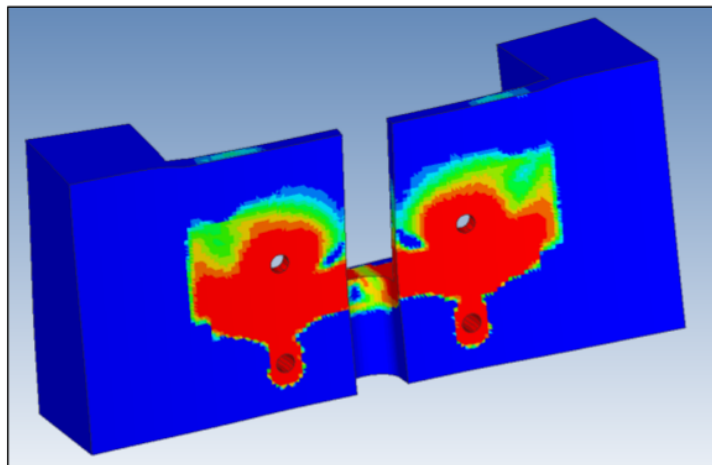


Figure 25 - Back Image of Stresses Experienced on Envelope (Rossiter, 2020).

6.3. Optimisation Results

Shown in Figure 26 is the optimised bracket. It is very apparent that material was removed substantially from the outermost areas, whilst still ensuring material was kept in the critical areas needed to fix the bracket to the rocket interface and also fix to the engineering work platform too.

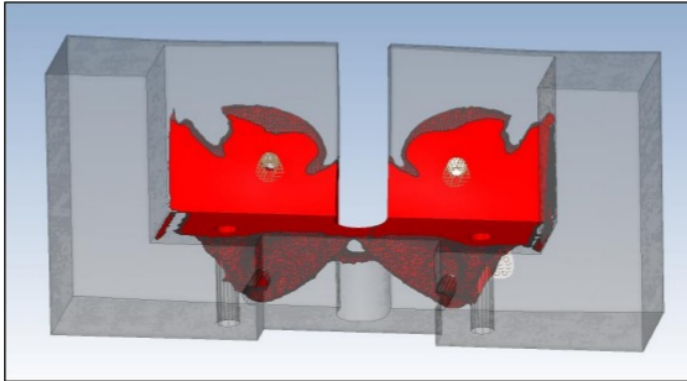


Figure 26 – Non-Smeared Optimised Bracket with Original Topology Region (Rossiter, 2020).

The optimised part showed a higher stress of 84MPa , a higher strain ratio of 0.2 and additionally a higher displacement value of 2.8mm . The higher stress nodes shown in Figure 27 can be disregarded as they were attached to the boundary conditions. The remainder of the model showed a stress of approximately 30MPa which was a more realistic output. Lastly, the optimised displacement value is higher than the original part because the bracket contains less material yet experiences a larger stress, therefore is less stable.

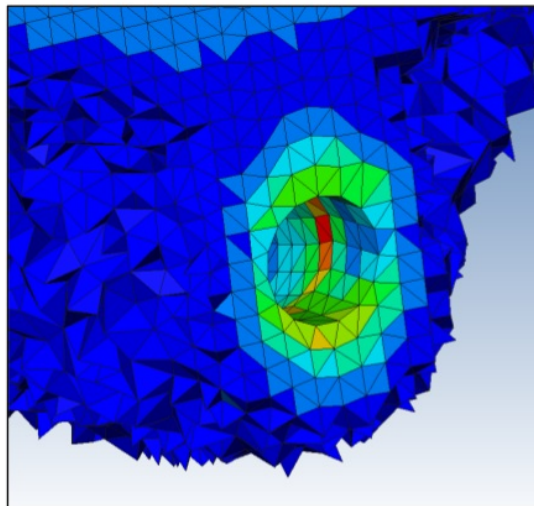


Figure 27 - High Stress Nodes shown at Boundary Conditions (Rossiter, 2020).

Student Number: P151615

The transfer of the optimised part from Design Studio to SolidWorks allowed further analysis. The mass of the optimised part was calculated in Equation 4 by using SolidWorks data shown within Figure 28. The new mass of the optimised part totalled 0.0333 Kilograms, which is a 27% lower than the upper limit and therefore passed.

Density = 0.00100 grams per cubic millimeter
Mass = 33.27904 grams
Volume = 33279.04435 cubic millimeters
Surface area = 15872.17870 square millimeters

Figure 28 - Optimised Part Properties from SolidWorks (Rossiter, 2020).

$$\begin{aligned} \text{Mass} &= \text{Volume} \times \text{Density} \\ \text{Volume into SI} &= 33279.04 \text{ Cubic Millimeters} \rightarrow 3.3279E^{-5} \text{ Cubic Meters} \\ \text{Density into SI} &= 0.001 \text{ Grams per Cubic Millimeters} \rightarrow 1000 \text{ Kilograms per Cubic Meters} \\ \text{Mass} &= 3.3279E^{-5} \times 1000 \\ \therefore \text{Mass} &= 0.03328 \text{ Kilograms} \end{aligned}$$

Equation 4 – Total Mass of Optimised Bracket (Rossiter, 2020).

Visual inspection of the optimised part allowed a quick, easy method to determine the areas with the minimum wall thicknesses. Then, the identified areas were measured within SolidWorks. Shown in Figure 29, the minimum wall thickness was 1.23mm therefore passed the design requirement.

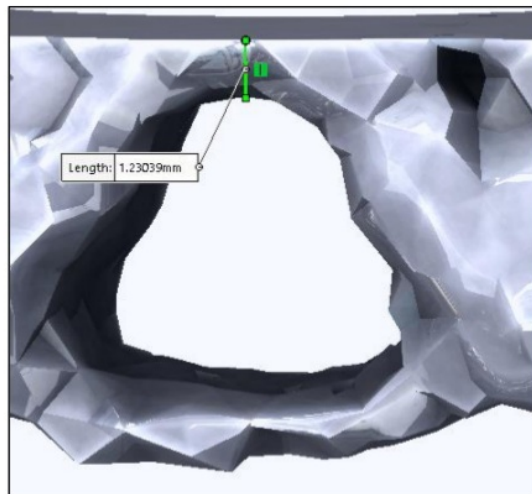


Figure 29 - Minimum Wall Thickness Value from SolidWorks (Rossiter, 2020).

Student Number: P151615

Lastly, on review it is apparent that two out of the total 6 bolt holes did not meet the minimum distance to edge requirement. As shown in Figures 30 and 31, two bolt holes only had an edge distance of 2.2mm at the outermost back edge, however the part would have passed if measured from the frontal image only. Review of inputted data in Design Studio is required to correct this error. Stress, strain and displacement result imply this design would pass however the design requirement was not met therefore this requirement failed.

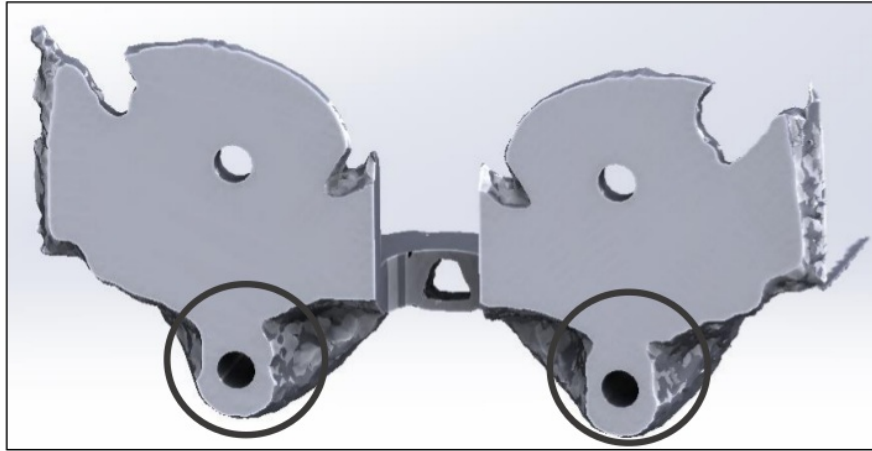


Figure 30 – SolidWorks Image Showing Minimum Hole Edge Distance Around Lower Holes (Rossiter, 2020).

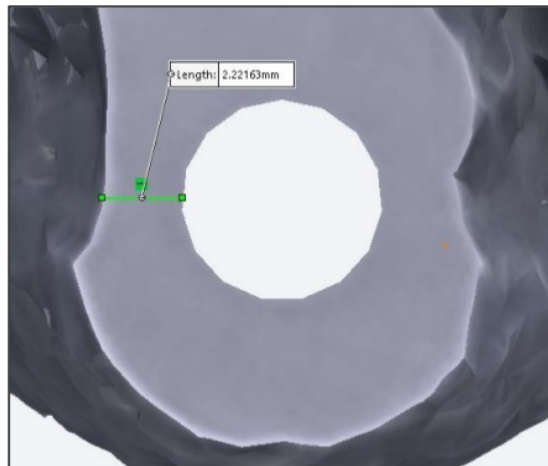


Figure 31 - Bolt Hole Surrounding Distance Measurement Measured within SolidWorks (Rossiter, 2020).

6.4. Improving Optimisation Results

10

Design Studio software was great for guiding the conceptual redesign in the right direction, however further work can be done to additionally improve. The design change of greatest priority is to ensure the minimum edge distance surrounding all bolt holes was increased to meet the design requirement.

The next design change would be to review the part and remove all unnecessary material to produce a cleaner, more professional finished part. See examples of areas where material should be removed in Figure 32.

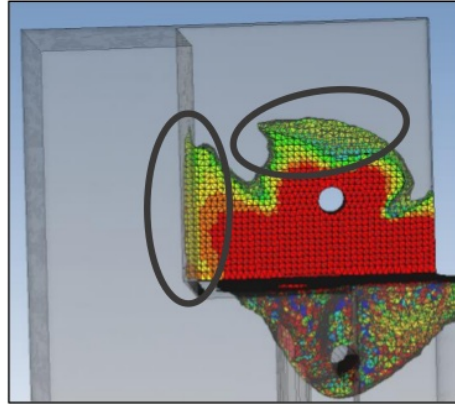
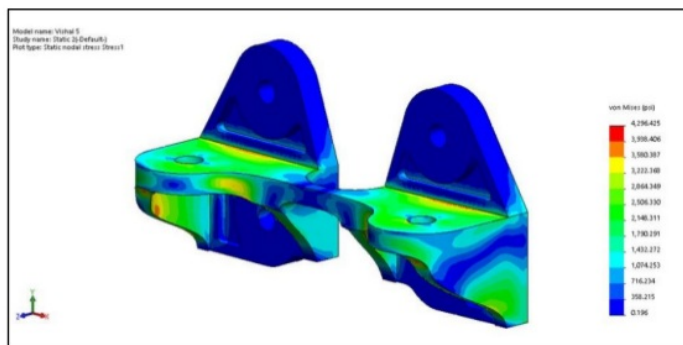


Figure 32 - Design Studio Image showing Wasted Material Remaining on Optimised Part (Rossiter, 2020).

Further design changes which could optimise the part could be the addition of ribs, ridges and gussets. Such design features can improve the stiffness and strength of load bearing features whilst reducing the material volume and therefore the 3D print time (Collins, 2009). A GrabCAD prize entry (United Launch Alliance, 2016) shown in Figure 33 for the same bracket redesigned shows perfectly how the use of side supports help transfer stress away from the bolt holes.



11

Figure 33 – GrabCAD ULA Bracket Design (United Launch Alliance, 2016).

Moreover, the shell design feature can be used to remove material from the inner body of model by keeping a small thickness to hollow the model. Shelling is a great method of reducing the volume of material used which could be very useful since minimising weight of the bracket will dramatically improve the weight to orbit ratio.

Lastly, the introduction of fillets or chamfers can improve both the cosmetic and mechanical strength of a part. Fillets are typically the preferred feature as sharp edges are eliminated that otherwise could be damaged or cause injury during handling. Fillets also have lower stress concentration factor than chamfers meaning that they distribute stress over a broader area therefore, filleted parts are more durable and are able to withstand larger loads (Insitute of Mechanical Engineers, 2016). See the redesign bracket winner from GrabCAD (United Launch Alliance, 2016) within Figure 34 for recommended use of fillets.

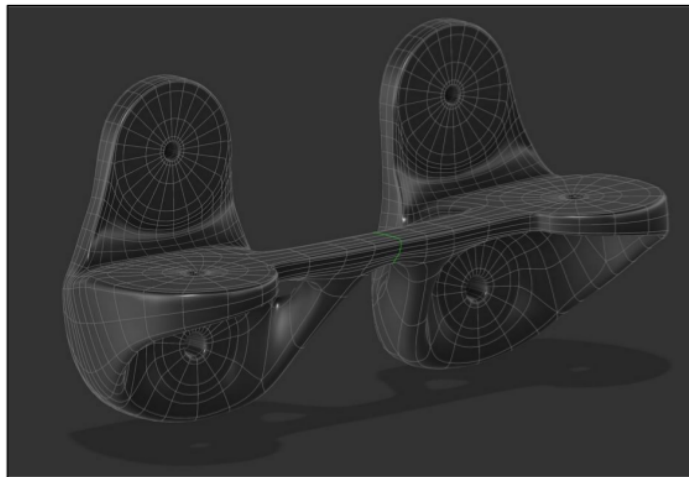


Figure 34 - GrabCAD ULA Bracket Design (United Launch Alliance, 2016).

It would be critical to repeat stress, strain and displacement analysis studies when any design changes are made to ensure the functionality and therefore safety of part is not affected.

Due to the part being manufactured by the method of 3D printing, there is a huge capability to produce designs which are impossible by tooling machines. 3D printed parts can develop from idea to production in a fraction of the time due to the removed time associated to generating tooling (R. J. M. Hague, 2000). The volume of time needed for a design process can be hugely reduced from the historic approach by the introduction of CAD and CAE led designs see Figure 35.

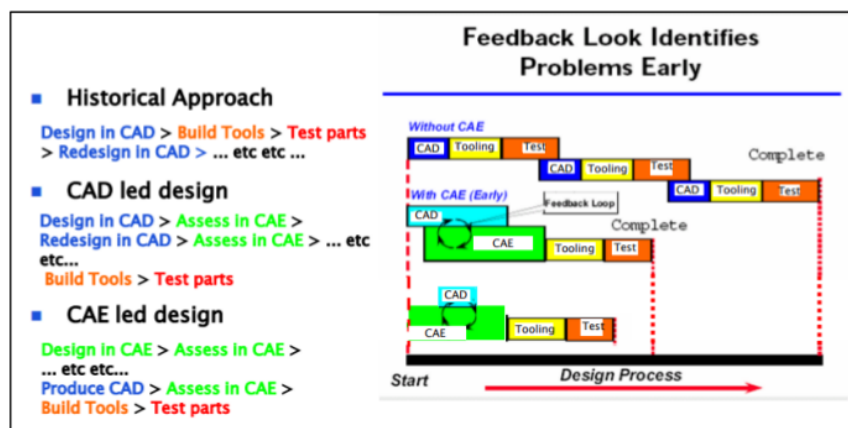


Figure 35 - Reducing Time for a Design Process (UWTSO ACM Module, 2019).

6.5. Critical Appraisal

The optimised part is moving in the correct design direction however, the error of bolt hole edging distance must be corrected unless simulation studies can prove that the part will function safely regardless of lesser value.

The optimisation studies were conducted using a draft mesh which was appropriate for conceptual work however, a finer mesh would reduce the volume of grid elements shown due to mesh element restrictions as shown in Figure 36. It is recommended to use a finer, higher quality mesh for further design work; the run time will increase but better results will be produced. High quality meshing is best for situations where the accuracy of the result needs to fall within a narrow margin (Kurowski, 2015).

12



Figure 36 – Image showing Grid Elements within Optimised Bracket Part (Rossiter, 2020).

To improve computational time, this conceptual study discounted any gravitational forces applied to the part due to the small target mass of only 0.0454kg. For improved accuracy of data, gravitational forces should be included.

On reflection of the entered material properties, it was noticed that Ultimate Tensile Stress (UTS) was missing. It is recommended to include such stress related property to improve the results of the CAE study.

It is also recommended to use a more thorough material thickness analysis tool such as the feature within SolidWorks shown in Figure 37, especially if using any shell techniques as thin material area could be hidden.

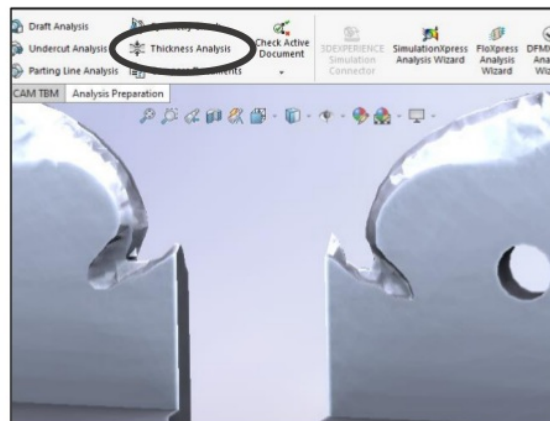


Figure 37 – Image showing Alternative Improved Method to Conduct Thickness Analysis (Rossiter, 2020).

7. Conclusion

The report has optimised the design of a support bracket used an Atlas V rocket. The bracket has the sole purpose of securing the engineering work platforms used during ground processing, therefore the redesign part needed to also be capable of withstanding the required functional design requirements.

All design requirements were input into Design Studio to conduct analysis of the original bracket, the results drove the design changes seen and described for the optimised part. The optimised part was equally critiqued against the design requirements; it is clear that design had improved and was moving in the right design direction. The report successfully reduced the component mass which resulted in less material required for 3D printing therefore reduced the manufacturing costs, but better still the rocket will use less fuel as the mass of the part has been reduced.

The analysis however did highlight one design error, the minimum edge distance around two bolt holes was lower than required. More work can be completed to either add material to meet the design requirements, or even complete further analysis to potentially prove that the design requirement is overly cautious and extra material around the bolt hole may not be required. Further design and analysis improvements can be made to further optimise the part as listed previously within the report.

The software package named Design Studio aided the design improvements by ensuring the conceptual designs developed logically by focusing on the inputted topology objectives. The software supported the construction of a more complex design that otherwise probably would not have been imagined. Advancements within Design Studio user knowledge will allow the bracket to be further optimised.

8. References

- Chang, K.-H., 2014. *Product Design Modeling using CAD/CAE*. First ed. Oxford: Academic Press.
- Chen, W. Z., 2012. *Advanced Mechanical Design*. third ed. China: Trans Tech Publications Ltd.
- Collins, J. A., 2009. *Mechanical Design of Machine Elements and Machines*. Second ed. United States of America: John Wiley & Sons.
- Hawk Ridgesys, 2019. *Adaptive Meshing*. [Online]
Available at: <https://hawkridgesys.com/blog/simulation-adaptive-meshing>
[Accessed 01 October 2019].
- Institute of Mechanical Engineers, 2016. Chamfer or Fillets Forum. *Engineering Forum*, 01 July, Eleventh (01), pp. 108-109.
- Komzsik, L., 2005. *What Every Engineer Should Know About Computational Techniques of Finite*. s.l.:CRC Press.
- Kurowski, P., 2015. *Engineering Analysis with SOLIDWORKS Simulation*. s.l.:SDC Publications.
- Louhichi, B., 2012. CAD/CAE integration: updating the CAD model after a FEM analysis. *Springer*, Third(03), p. 79.
- Meguid, S. A., 1987. *Integrated Computer-Aided Design of Mechanical Systems*. First ed. United Kingdom: Springer Science & Business Media.
- Quek, G. L. a. S. S., 2003. *Finite Element Method: A Practical Course*. Fourth ed. Oxford: Butterworth Heinemann.
- R. J. M. Hague, P. E. R., 2000. *Rapid Prototyping, Tooling and Manufacture*. Second ed. United Kingdom: iSmithers Rapra Publishing.
- Rossiter, 2020. *CAE Study*. [Art] (UWTSD).
- Rossiter, 2020. *Equation*. [Art] (UWTSD).
- SolidWorks Help, 2019. *SolidWorks*. [Online]
Available at:
https://help.solidworks.com/2018/English/SolidWorks/cworks/IDC_HELP_MESHESOLID.htm
[Accessed 01 January 2020].
- SolidWorks, 2020. *SolidWorks Mesh Analysis*, United Kingdom: SolidWorks.
- STRATASYS, 2017. *Ultem 9085 - Material Data Sheet*, USA: Stratasys.
- Stratasys, 2019. *Stratasys Ultem 9085*. [Online]
Available at: <https://www.stratasys.com/materials/search/ultem9085>
[Accessed 01 January 2020].
- U.S. Department of Health & Human Services, 2017. *Body Measurements - US Data*, USA: National Center for Health Statistics.
- United Launch Alliance, 2010. *Atlas V Launch Services User's Guide*. First ed. Denver: ULA.

Student Number: P151615

United Launch Alliance, 2016. *GrabCAD: 3-2-1 Liftoff! ULA Rocket Hardware Challenge*. [Online]
Available at: <https://grabcad.com/challenges/3-2-1-liftoff-ula-rocket-hardware-challenge>
[Accessed 01 January 2020].

UWTSD ACM Module, 2019. *Moodle, UWTSD*. [Online]
Available at: <https://moodle.uwtsd.ac.uk/course/view.php?id=2498>
[Accessed 17 January 2020].

ACM Assignment 2 - Complete

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

67 /100

PAGE 1

PAGE 2



Comment 1

This is fine as this assignment was to develop a conceptual design, not a detailed (finished) design.

PAGE 3

PAGE 4



Comment 2

There is no need to reference yourself like this when you are presenting information for the first time.



Comment 3

Be consistent with your formatting.

PAGE 5

PAGE 6



Comment 4

Is this section 3 or 4?

QM

1. Secondary(+)

Good secondary research

QM

2. Creating the UDL

By applying the force directly to an area that you have defined you are pre-empting the design. Ideally you would apply the load to a 'platform' and then set up contacts between the platform and the bracket. Alternately you could have taken the udl and split this between the two holes. You are then allowing the topology to determine where material should be placed, rather than you defining this by choosing the area that the load is applied over.



Comment 5

Why have you added these constraints? You must justify decisions such as this.



Comment 6

What does this figure add?



Comment 7

This stress is potentially unrealistically high as it is at the attachment point to the boundary conditions that are unrealistically stiff.



Comment 8

why is your font inconsistent here?



Comment 9

good

PAGE 18

PAGE 19

PAGE 20



Comment 10

Yes. Studies such as this inform the design only.



Comment 11

Good research. It is good to see the winning design so that this can be compared to your design. It would be interesting to know if topology optimisation was used in this design.

PAGE 21

PAGE 22



Comment 12

Good. Yes initial analysis is generally carried out with quite a coarse mesh and then subsequent analysis can be carried out with a more refined mesh.

PAGE 23

PAGE 24

PAGE 25

GRADING FORM: ACM ROCKET BRACKET

NIA CATRIN DAVID

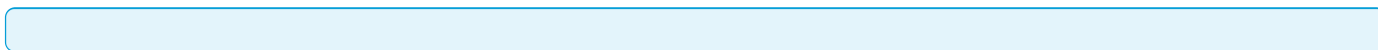
67.10

RESEARCH-INFORMED LITERATURE



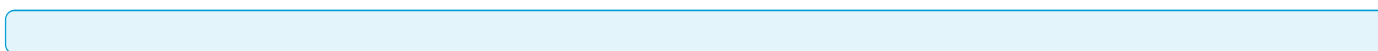
13

KNOWLEDGE AND UNDERSTANDING



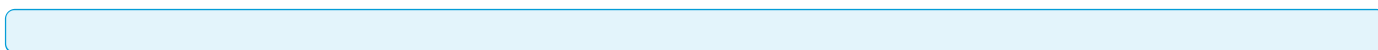
13.6

ANALYSIS



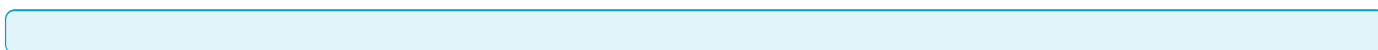
20.1

PRACT. APP. & DEPLOYMENT



13.6

SKILLS FOR PROF. PRACT.



6.8