BUPE ZEBEDIAH CHAPULA

FEA REPORT BIKE CRANK

6. FEA setup

1.Introduction:

This report will detail on the design and development used to create a high-performance crank arm for BMX bicycles, including the original concepts, simulation, optimization, and final design proposal.

Various tasks had to be completed before getting to the final design, the initial designs had to go through different processes before it could be considered ready for manufacture. Making the product more effective for its use therefore optimized.

2.Specifications:

A comprehensive set of criteria from the client was combined and refined to create Table 1, the project specification. It provides essential conditions that the crank arm needs to be considered acceptable. This table will list the locations and methods by which the key performance indicators (KPI) have been met.

Performance	Requirement	Achieved Yes/No	Evidence
Size	client weight is 90 Kg Max component weight is 300 g	yes	Section 9.1 Stress simulation data
Maintenance	Max footprint detailed in Fig.1	yes	Section 10 Engineering Drawing
Finish	No maintenance during lifespan	yes	s section 6.1 and 9.1 Well below fatigue limit
Materials	Corrosion resistant	yes	Section 6.1 Al resistant to Water
Transportable	Easily recyclable	yes	l 7075 used, will not be damaged during transit.
Aesthetics	Must present an image of high-end performance	yes	Section 3 Comparable to other high end crank arms.
Customer	BMX enthusiasts	yes	Section 10 Complies with spec
Safety	Should not have any sharp protrusions, safety factor of 4 implemented from design loading	yes	Section 9.1 Fos data provided
Environment	10 to + 40 deg C, water, and dust resistant.	yes	Section 6.1 Al 7075 more than acceptable in these condition

Ergonomics	C compatible with existing mounts and peddles	yes	Section 10 Mounting unchanged.

Table 1

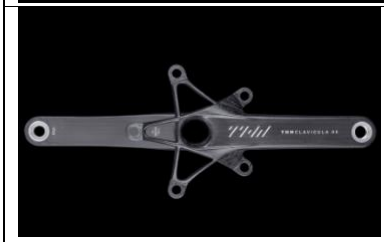
3.Competitor analysis:

Before undertaking initial design conceptualisation an overview of currently available crank arms was undertaken. These designs were then evaluated against the following key design parameters:

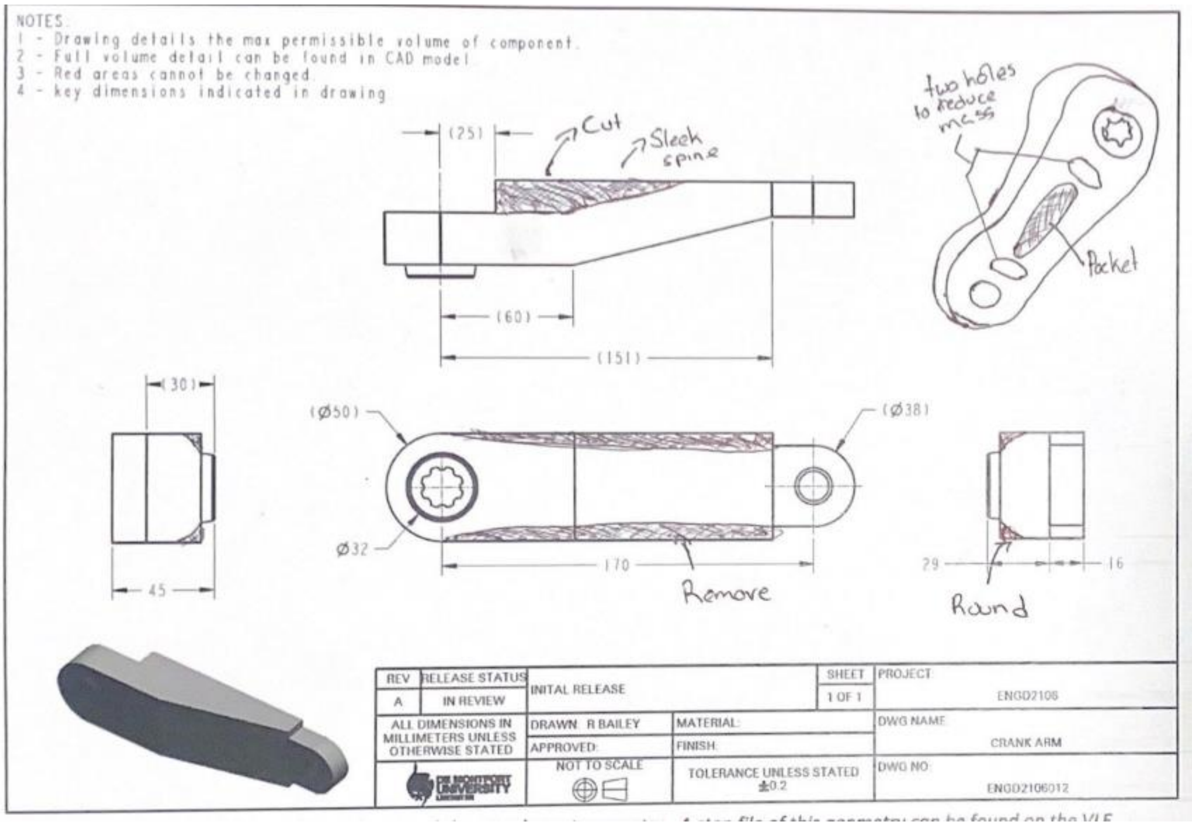
- Mass
- Aesthetics
- Sustainability
- Cost

These characteristics where then weighted (High importance 5, low importance 1), and the products rank ordered Table 2 below details the analysis undertaken. Using this information an informed decision can be made regarding the materials and the overall appearance of the component.

Criteria	**Mass 5**	**Aesthetics 4**	**Sustainability 3**	**Cost 1**	**Total**
Product					
 Material: Aluminium Weight: 714/690g Aesthetics: Sleek high end Price: £959.99 Link: DURA-ACE HOLLOWTECH II Crank set 2x12-speed | SHIMANO BIKE-EU	3 x 5	4 x 4	3 x 3	1 x 1	41

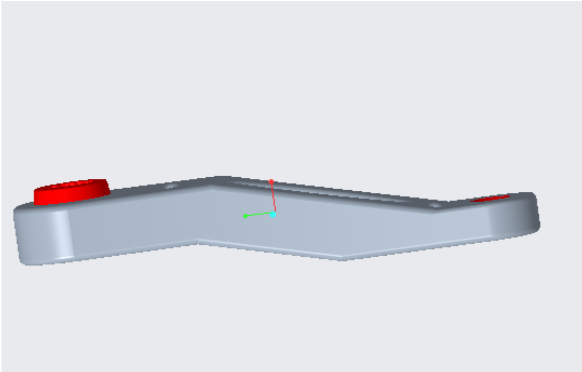
 Material: Aluminium Weight: 630g Aesthetics: Ordinary design Price: £692 Link: RED Crank set | FC-RED-D1 | SRAM	3 x 5	2 x 4	3 x 3	1 x 1	33
 Material: 7075 T6 aluminium Weight: 818g Aesthetics: Basic but smooth design Price: £192.05 Link: Vision Track 1X BB386EVO Crank set - 49 teeth - black | BIKE24	2 x 5	2 x 4	4 x3	5 x 1	35
 Material: Full Carbon fibre Weight: 293g Aesthetics: Basic design Price: £1187 Link: CLAVICULA SE ROAD - THM Faserverbund-Technologie GmbH	5 x 5	2 x 4	5 x 3	1 x 1	49

4.Design conceptualisation:



5. Initial CAD design:

Using the given data, market research and the initial designs, a CAD models were created. The designs kept the important mounting fixing as specified by the initial drawing. The component mass is 488g. Design A was the original design while design B was created after analysing data obtained from A.

.  get B!!!!!!!!!!!!!!!!!

A)

Figure 2: Shows the two initial designs and b.

6.FEA setup:

6.1 - Material

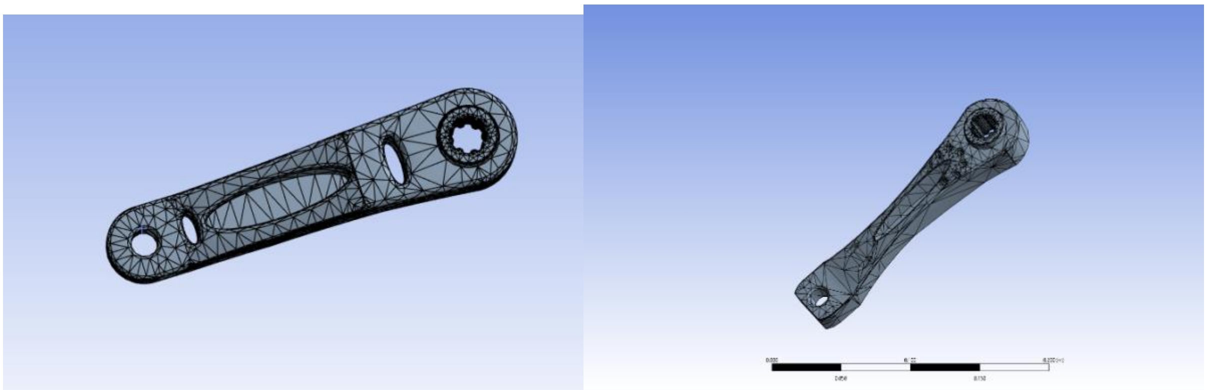
The material selected was Al 7055 which is recyclable and susceptible to corrosion, more importantly its light weight and strength attributes to it being picked. Table 3 below details some of the key properties of the material used during simulation.

Table 3:

Property	Value
Density	2.85 g/cm3
Youngs Modulus	425-593 MPa
Poisson’s ratio	0.33
Yield Strength	593 MPa
Corrosion resistance	Excellent
Fatigue strength 10^7 cycles	185 MPa

6.2- Meshing

For Both initial designs A and B because of their geometry auto mesh was used in the simulation and produced tetrahedral mesh. No mesh sixing in specific was using during the analysis of both designs.



A) B)

Figures 3 & Figure 4: Auto mesh used in simulation.

6.3 – Boundary Conditions

When conducting the simulation on the designs, the following boundary conditions were applied. A of 1000 N was applied to the pedal hole using the bearing load function. 1000 N is used considering the clients mass of 90 kg, taking gravity into to consideration g=10.

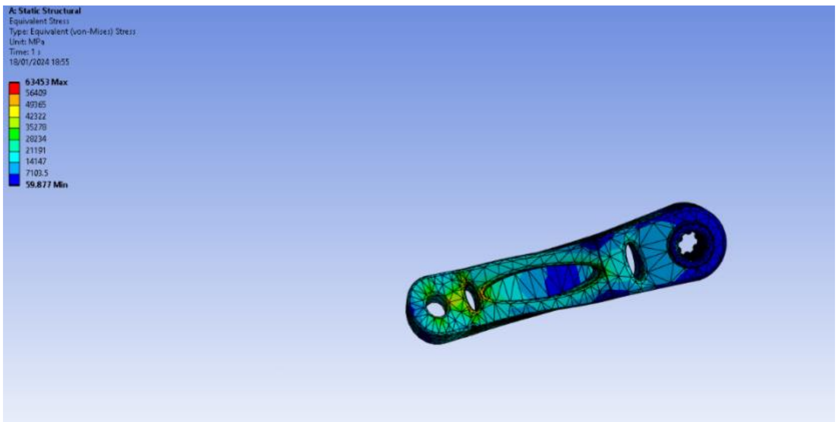
=90 x 10 = 900N

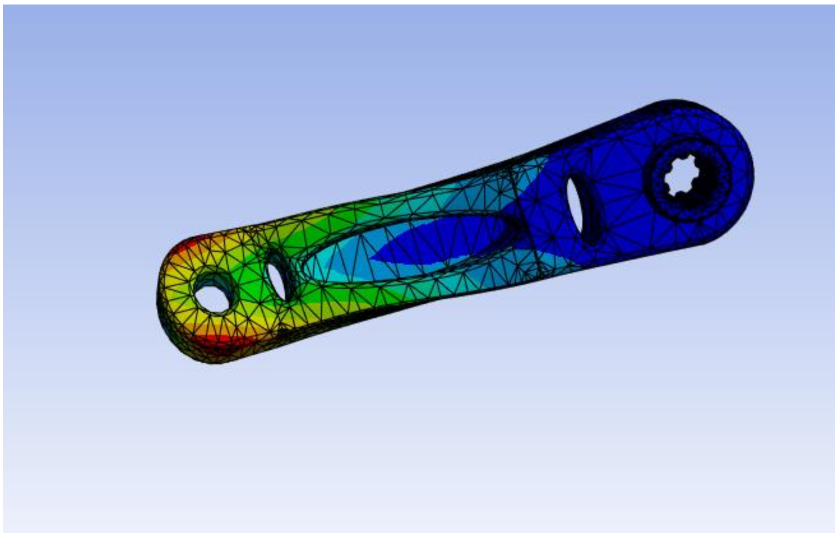
Now, considering any extra weight that could be on the client the force value raised by 100N to leave room for any complications.

Next a fixed Support was added to the crank shaft during the simulation to help more accurately depict how the force will be distributed on an actual bike.

7 Initial results:

Below we see three images after the simulation has been run the first contain the maximum equivalent stress 63.43 MPa we can also see Fos (Factor of safety) of 11.908 indicating further mass can be deducted from the product. It is also clear that there is some deformation formed.





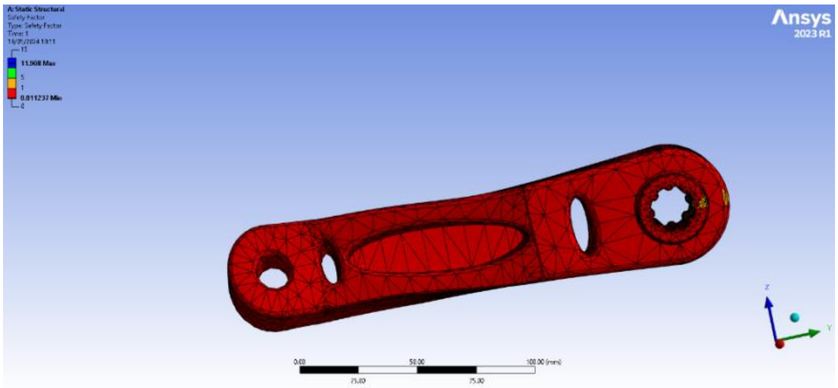


Figure5.

Next, we have design B which is optimised with less mass and we see there is a slight increase in the Maximum stress where it has now risen to 70.123MPa. While the Fos of part B reduced to 9.292 which is still above the required amount.

Mass became 285g, the design b is better however by lowering the max stress we can allow more room for the crank to not exceed its yield strength. Therefore, there was need for some more improvident.

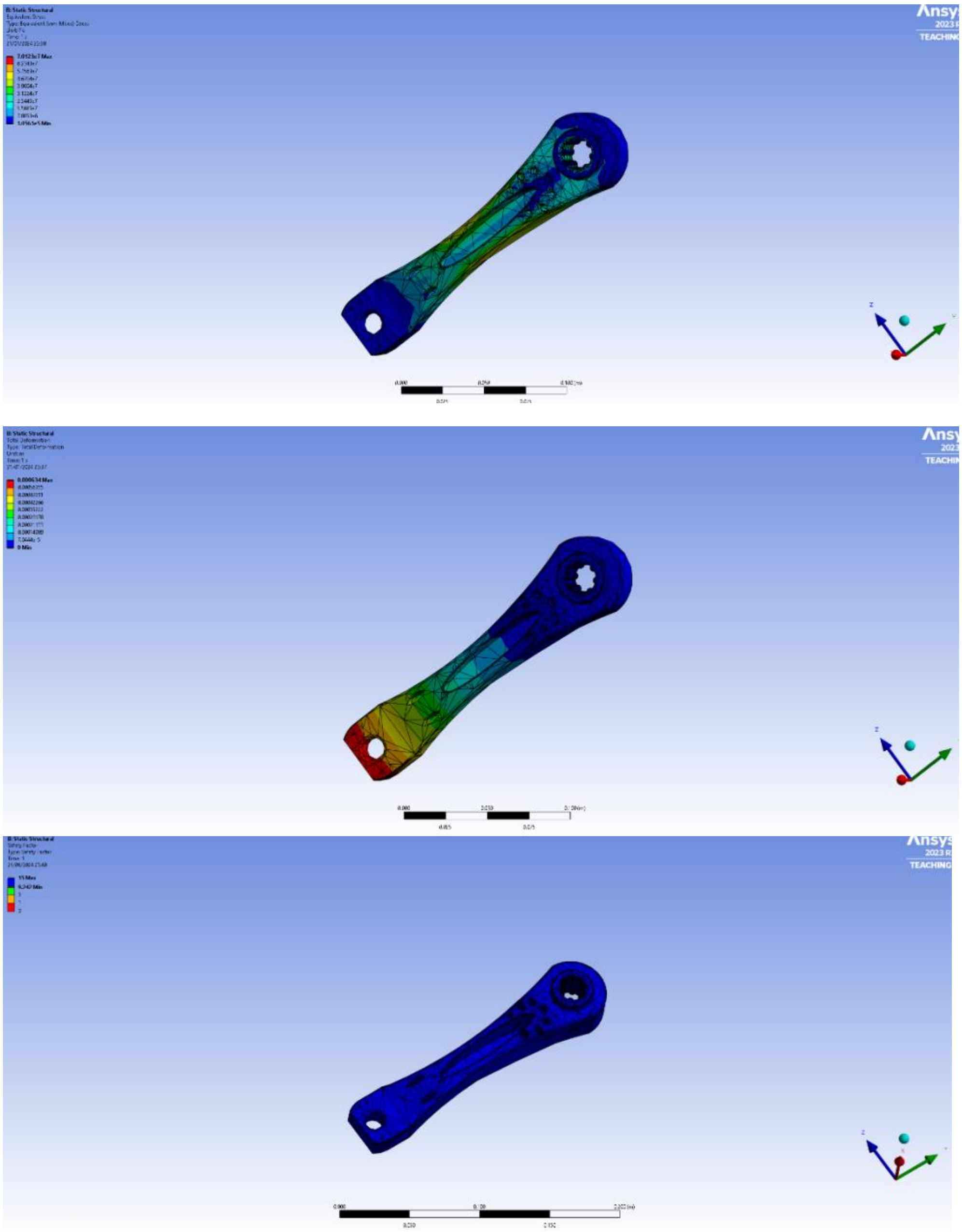


Figure 6

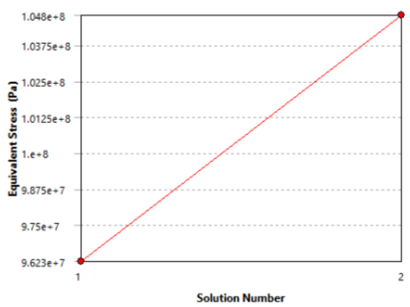
However, the design of the Aesthetic of the pedal was the only factor needing to be considered as design B did not match up to the high-end standard but adequate mass and data from simulation. The high Fos in A meant that mass could be reduced hence the design B being not as wide and edges cut differently.

Aluminium was not the only metal tested titanium T6 was also tested in the simulation however due to its high density which is almost twice that of aluminium it became hard to deduce mass and maintain an acceptable safety factor.

7.1 Convergence analysis

The auto convergence tool was implemented to check the Stress convergence, The results can be seen in Figure 6.

Convergence History



	Equivalent Stress (Pa)	Change (%)	Nodes	Elements
1	9.623e+007		9256	4896
2	1.048e+008	8.5283	21380	12229

Figure 8

8.Design optimization

After the two initial designs were run and analysed more modifications were made to the product to reduce the mass to 222 g and potentially maintain a safety factor above 4 and have a more aesthetic design:

9.Meshing

When optimized we did not use auto generate mesh but here the mesh was refined with a value of 15. Trying to keep the safety factor above the required amount.

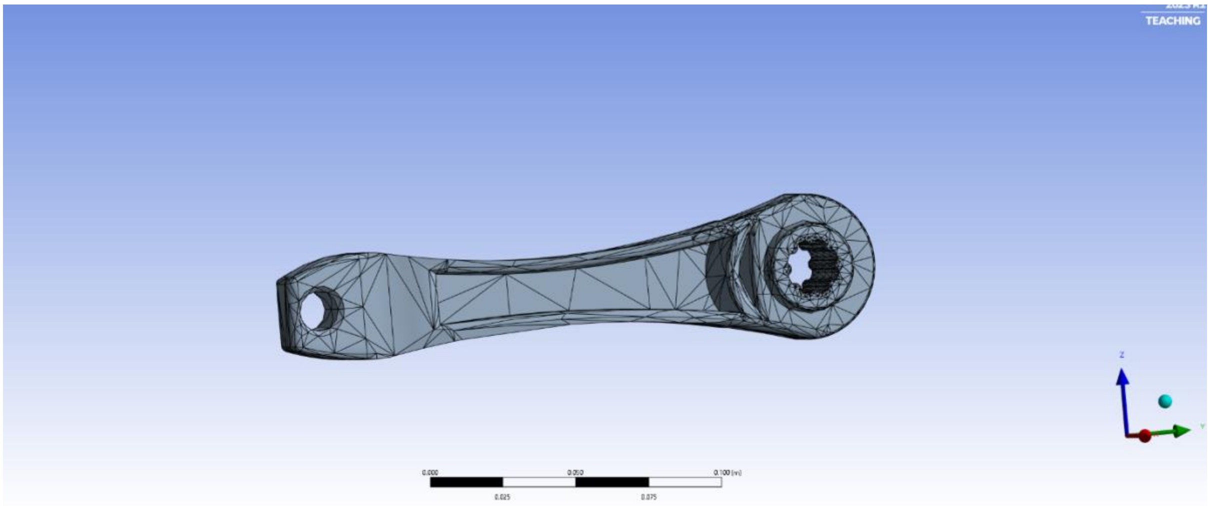
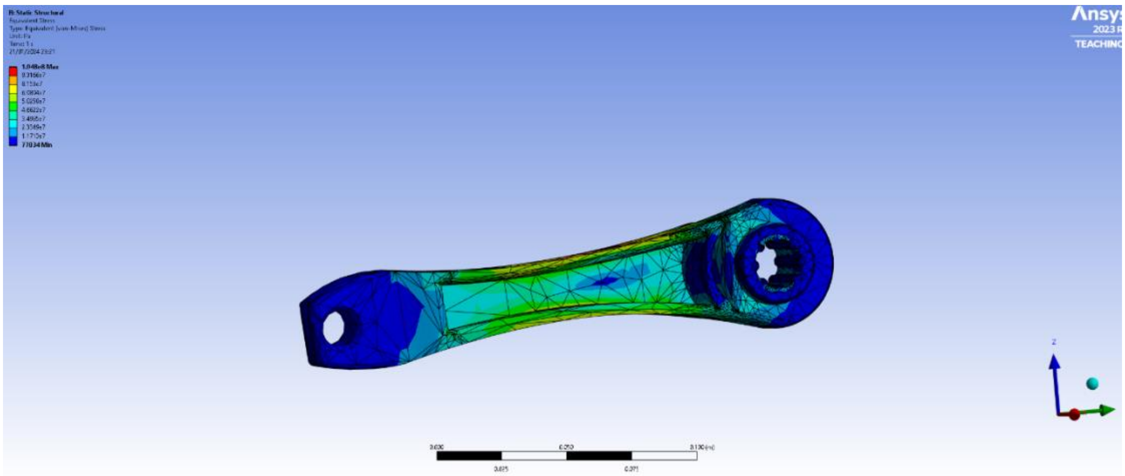


Fig 10.

9.Final Design, results, and recommendation

9.1 Dinal design

In the optimized design see even more refined results, the maximum stress reduces by about 60MPa and drops to 10.43 MPa, which intern the safety factor also dropped to 6.18 which is still above the required amount. All boundary conditions were kept constant for each of the three simulations.



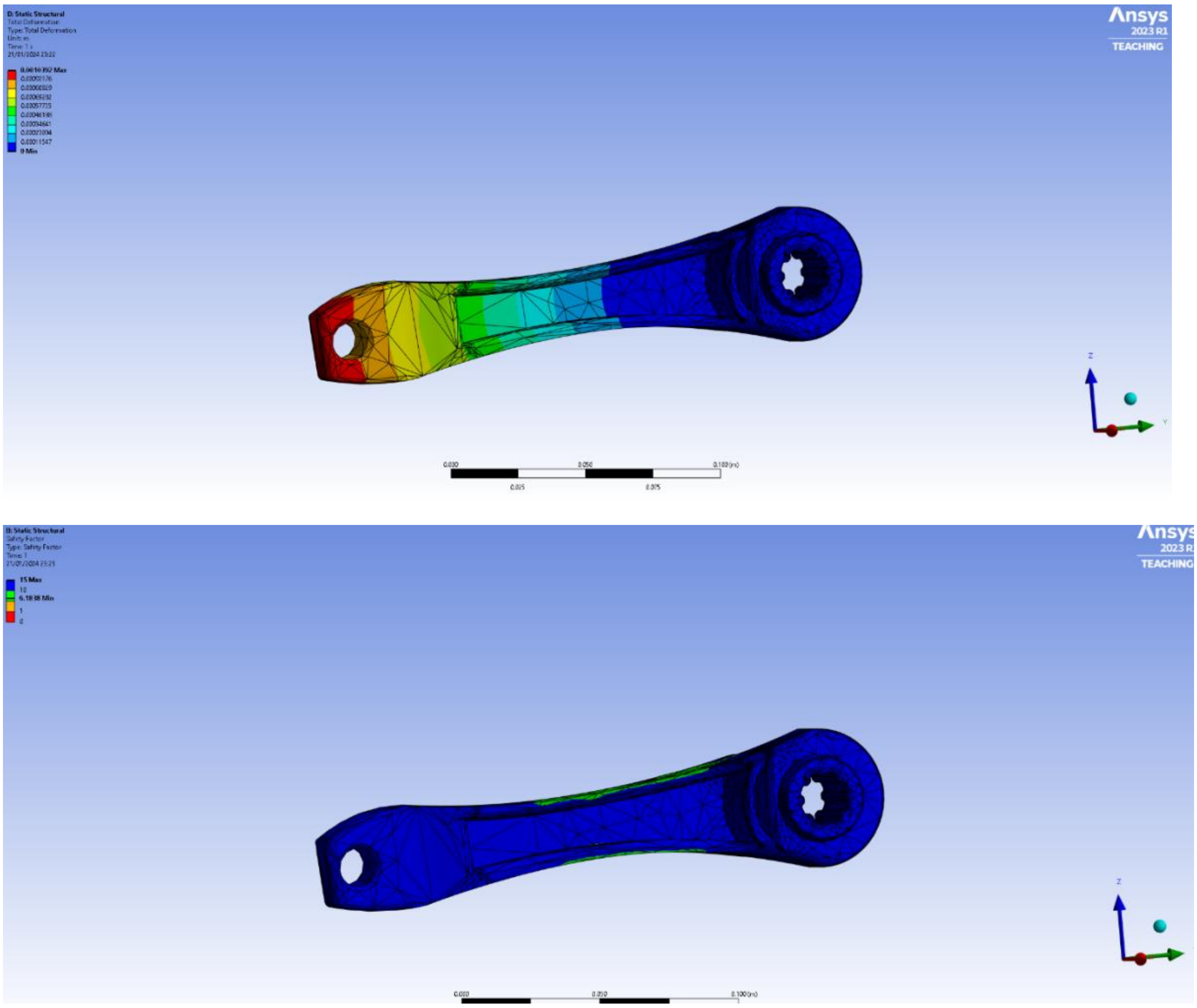
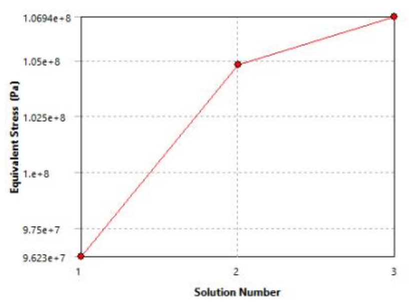


Fig 11

Additionally, the mass of the design also drops to 222g which is excellent in terms of the required mass from the client. The design is sleeker and more simplistic though it is not an ordinary design.

All customer requirements are met in the final optimized design as seen in the figures 11 above. Below we have the Convergence data for the final product.

Definition	
Type	Maximum
Allowable Change	5. %
Results	
Last Change	2.0236 %
Converged	Yes



	Equivalent Stress (Pa)	Change (%)	Nodes	Elements
1	9.623e+007		9256	4896
2	1.048e+008	8.5283	21380	12229
3	1.0694e+008	2.0236	37914	22820

Fig 12