PROJECT:

Geometrical Optimization of a mechanical component using computer aided engineering concepts (Shape Optimization).

REAR KNUCKLE JOINTS

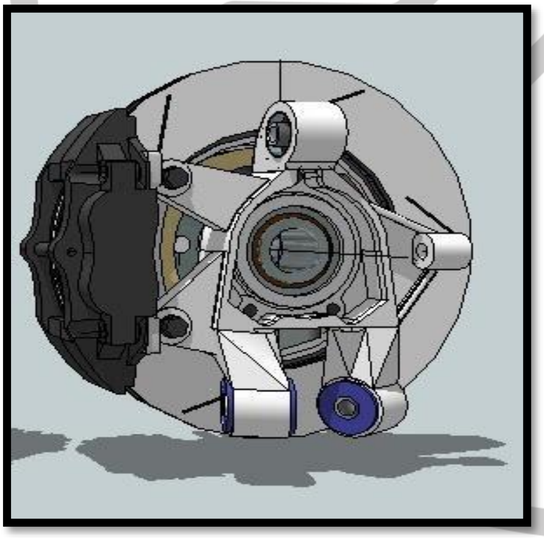
DESCRIPTION:

In automotive suspension, a steering knuckle or upright is that part which contains the wheel hub or spindle, and attaches to the suspension and steering components. The terms spindle and hub are sometimes used interchangeably with steering knuckle, but refer to different parts.

The wheel and tire assembly attach to the hub or spindle of the knuckle where the tire/wheel rotates while being held in a stable plane of motion by the knuckle/suspension assembly.

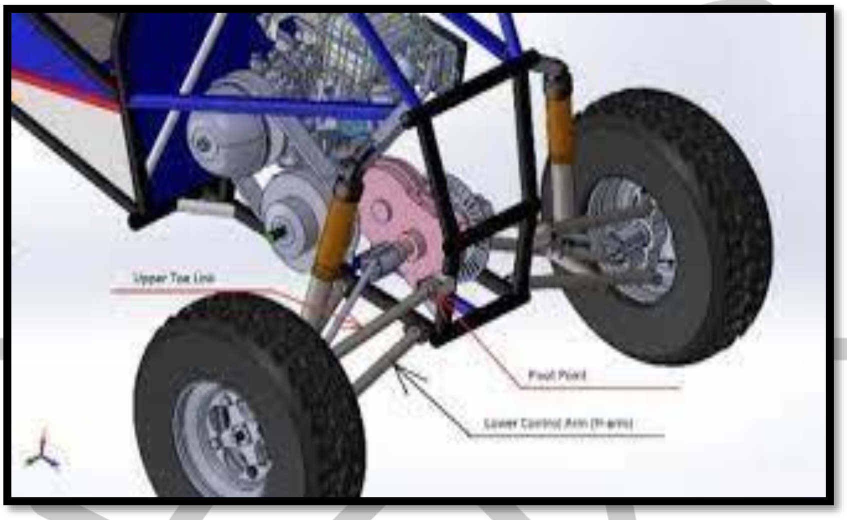
The knuckle joint holds the responsibility to transfer load and maintain the uprightness of the suspension system as well as the H-arm or the FISHBONE.

IMAGES FOR KNUCKLE JOINTS:

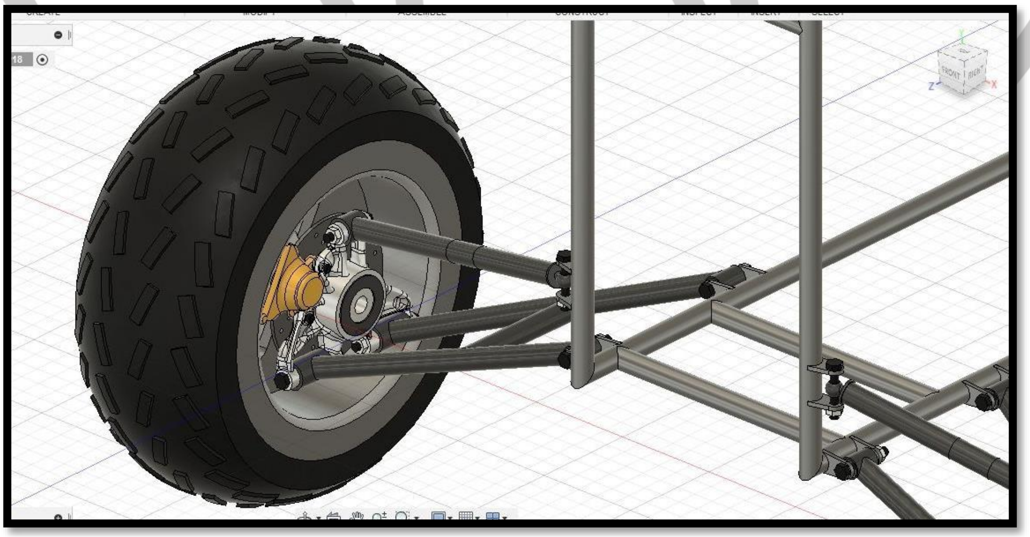


ASSEMBLY DESCRIPTION

These joints are utilized to connect the rods where the axes coincide or they have to intersect and must lie in one plane. These are the major parts where it limits the angular movement between the rods about the axis of the pin and to transmit the axial force. These rods are constrained to tensile stress and yield stress where the selection of materials and the pin is been subjected to shear stress and bending stress. It proves strength is the major criteria to select the pin. The objective of this research is to design and analysis the structural deformations in a Knuckle joint. Here the Knuckle joint is designed using SOLIDWORKS and analysed using ANSYS.



The joint connecting wheels and the H-ARM.



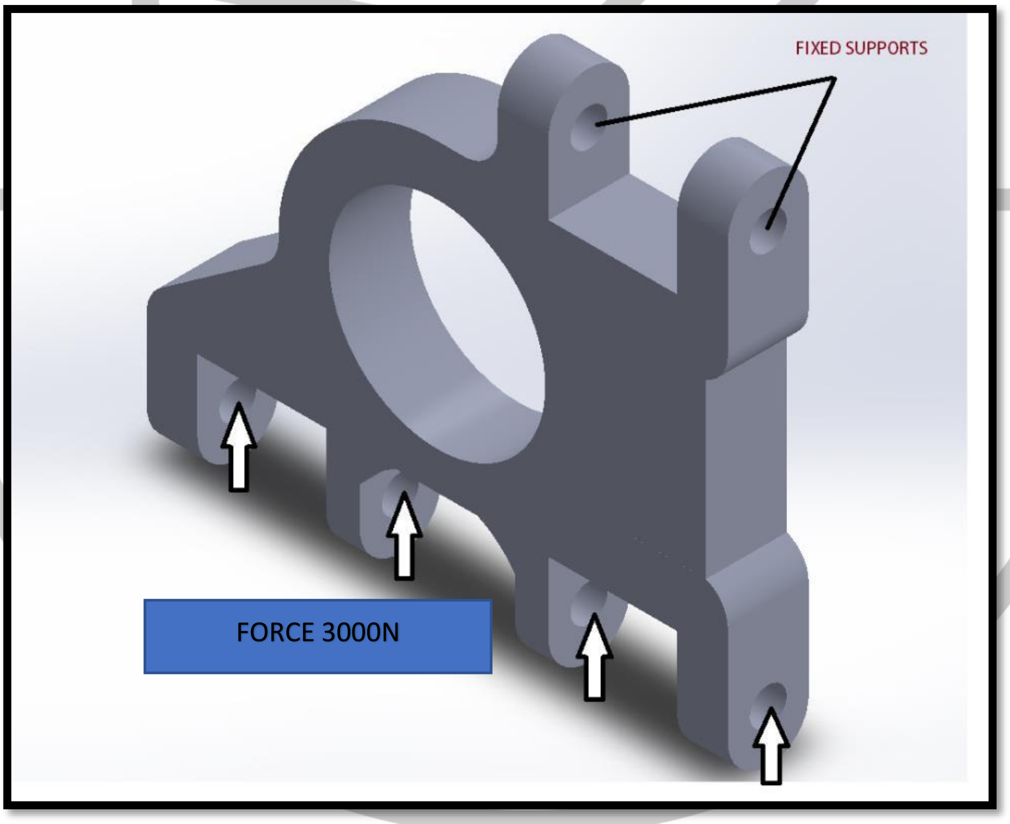
ASSEMBLY WITH THE CHASSIS

DESIGN FOCUS

The design focus of our project is for an off-road buggy, with weight up-to 200kg.The design focus is to simplify the shape with utmost weight carrying capacity of 300kg considering impact loads and terrain aspects.

The dimensional constraints were:

Connection with camber rod arms of radius 5.5cm, as for fixed support and 4 holes of radius 5.5 cm for transferring load. Thus, a base model geometry was created using SOLIDWORKS.



1. MATERIAL SELECTION:

The material selected for the Knuckle joint is Aluminium 7075. Properties for the material is shown below.

Young's modulus MPa	Poison's ratio	Bulk modulus MPa	Shear modulus	Density gm/cu.cm	Tensile Yield strength MPa
71700	0.33	70294	26955	2.81	520

2. CONSTRAINTS:

The analysis was carried out on the component by fixing the pivot points of knuckle, i.e., where the control arms are attached to it. The two holes with radius 5.46 were given fixed support.

3. LOADS:

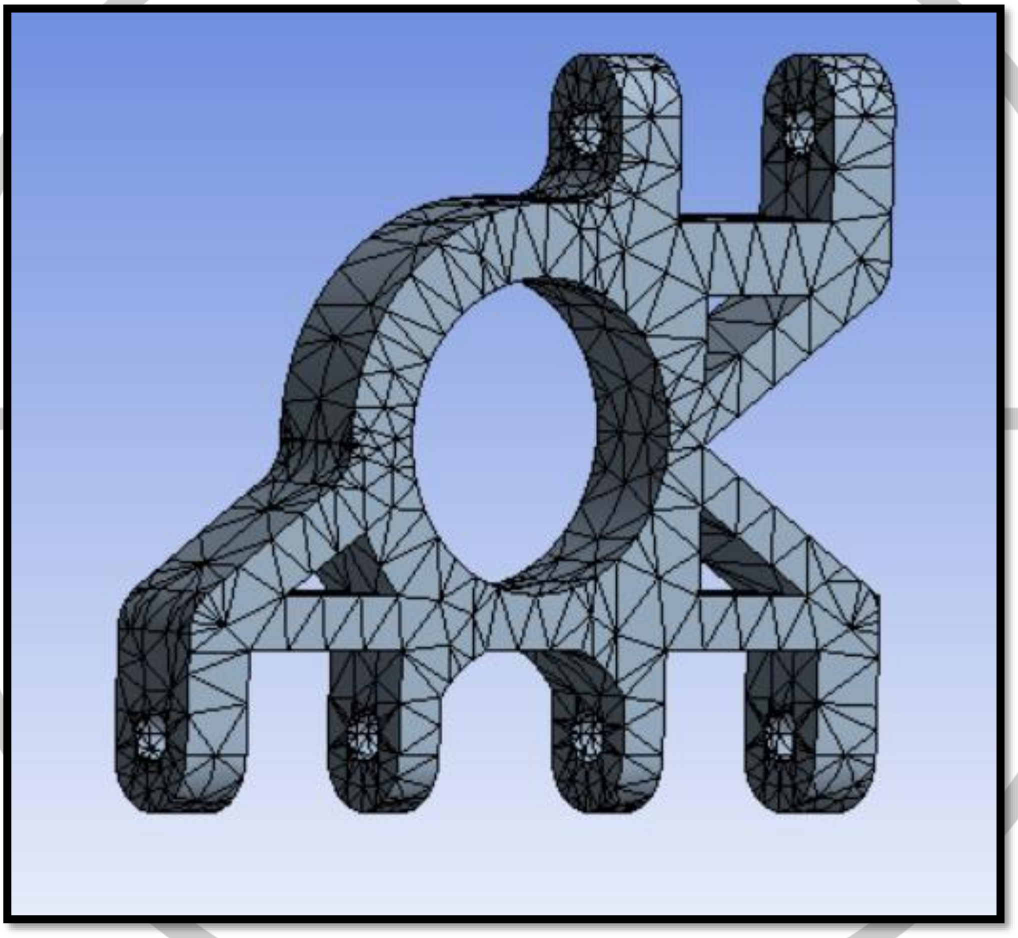
The knuckle, which connects the wheel to the steering and suspension systems, is one of the most important parts of the chassis and has a critical effect on the handling and steering characteristics of the vehicle. Modern vehicles rely on the use of lightweight designs to improve the energy efficiency. We consider a load of 3000 N acting upwards, on the knuckle joint at the four holes with radius 5.46.

4. PRESERVE REGION:

Certain areas of the Knuckle joint geometry must remain unchanged at certain critical areas, in this case, the mounting points and the hub. Setting up "Preserve Region" on those mounting points and the hub tells the software not to change the geometry around those areas. Hence, we set up regions around the mounting points and hub of our knuckle joint.

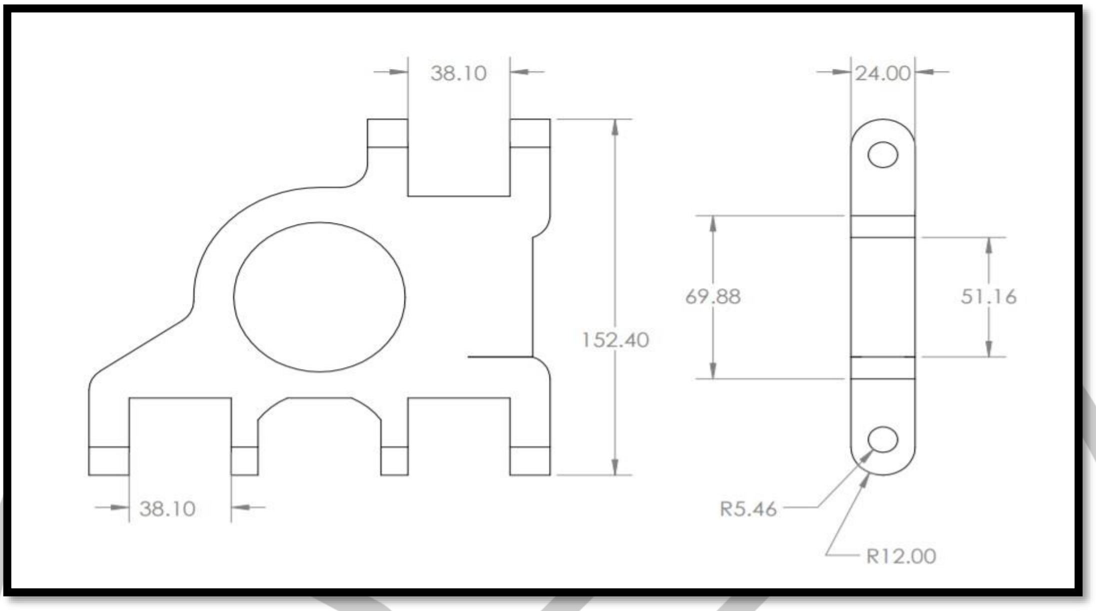
5. MESHING AND SOLVING:

Meshing of Knuckle Joint made by ANSYS The basic need for ANSYS analysis is to divide the whole section into many 4 Nodded tetrahedral elements. This will enable us to analyse the stress and strain of the components and various points of the said components. In the present case number of nodes was 17254 and the numbers of elements were 9931. A typical drawing of the meshing of the knuckle joint is shown

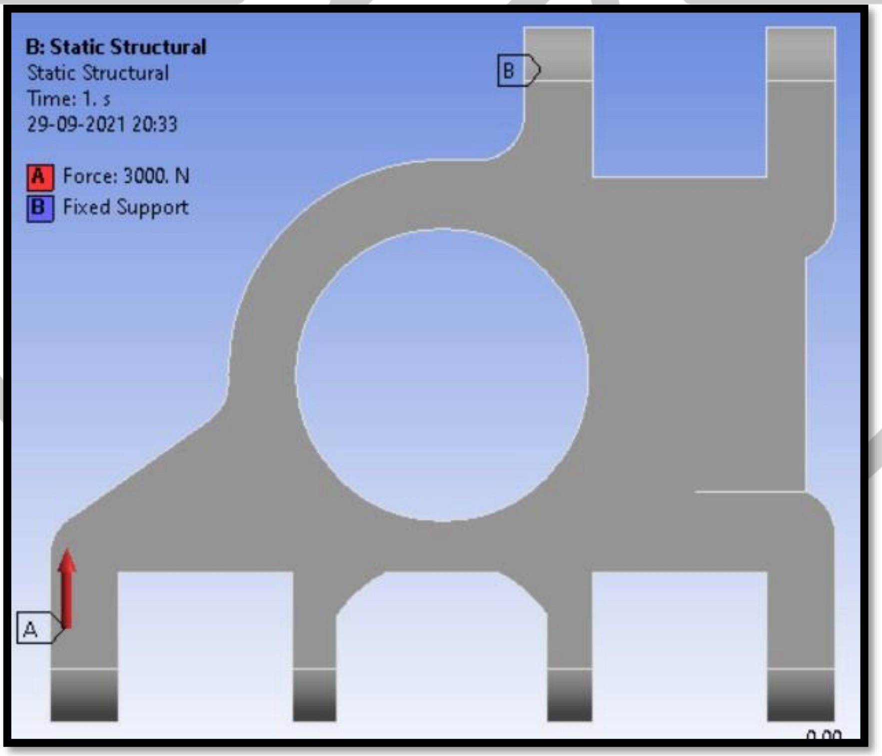


Analysis:

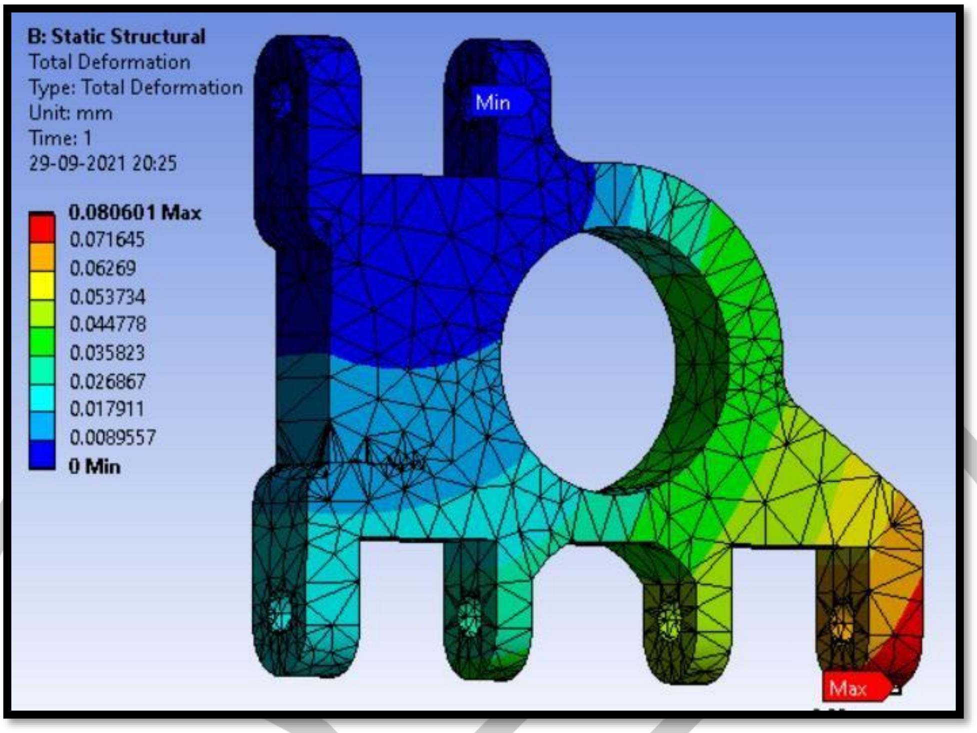
ITERATION-1

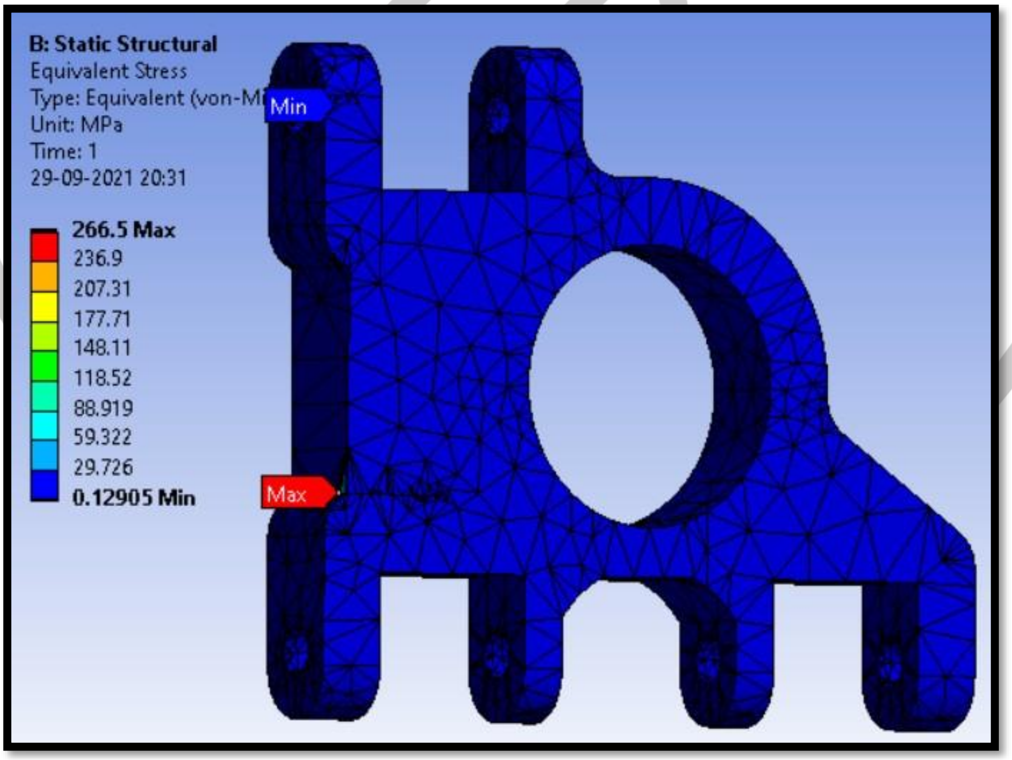


STATIC STRUCTURE ANALYSIS:



OUTCOMES:


B: Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
29-09-2021 20:25
0.080601 Max
0.071645
0.06269
0.053734
0.044778
0.035823
0.026867
0.017911
0.0089557
0 Min
Min
Max


B: Static Structural
Equivalent Stress
Type: Equivalent (von-M
Unit: MPa
Time: 1
29-09-2021 20:31
266.5 Max
236.9
207.31
177.71
148.11
118.52
88.919
59.322
29.726
0.12905 Min
Min
Max

RESULT:

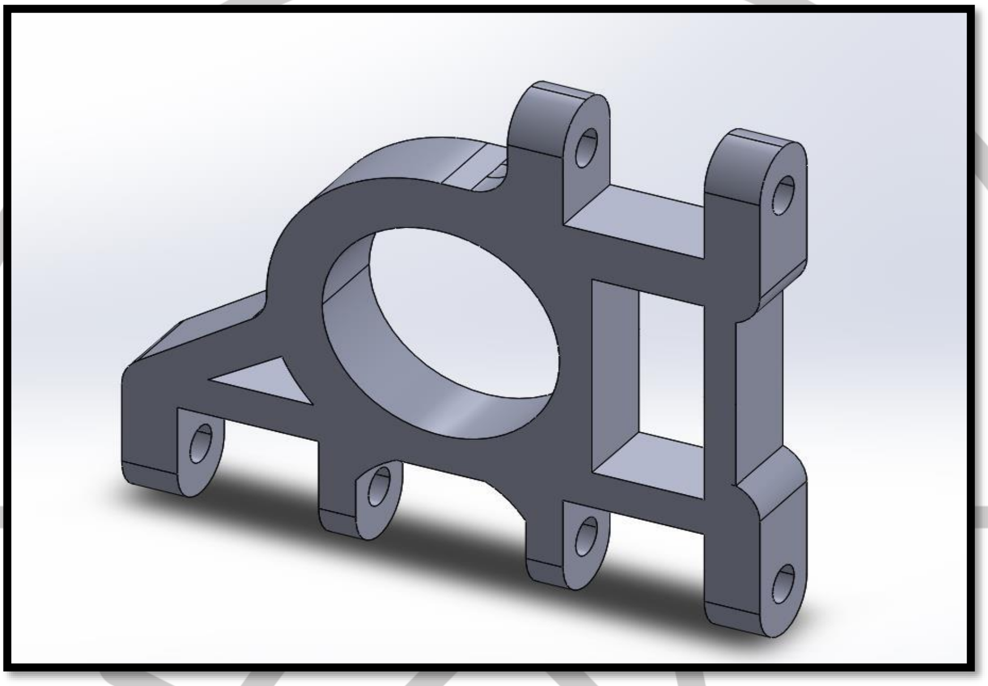
Total deformation (mm) max	Equivalent stress (MPa) average:
0.0806	266.5

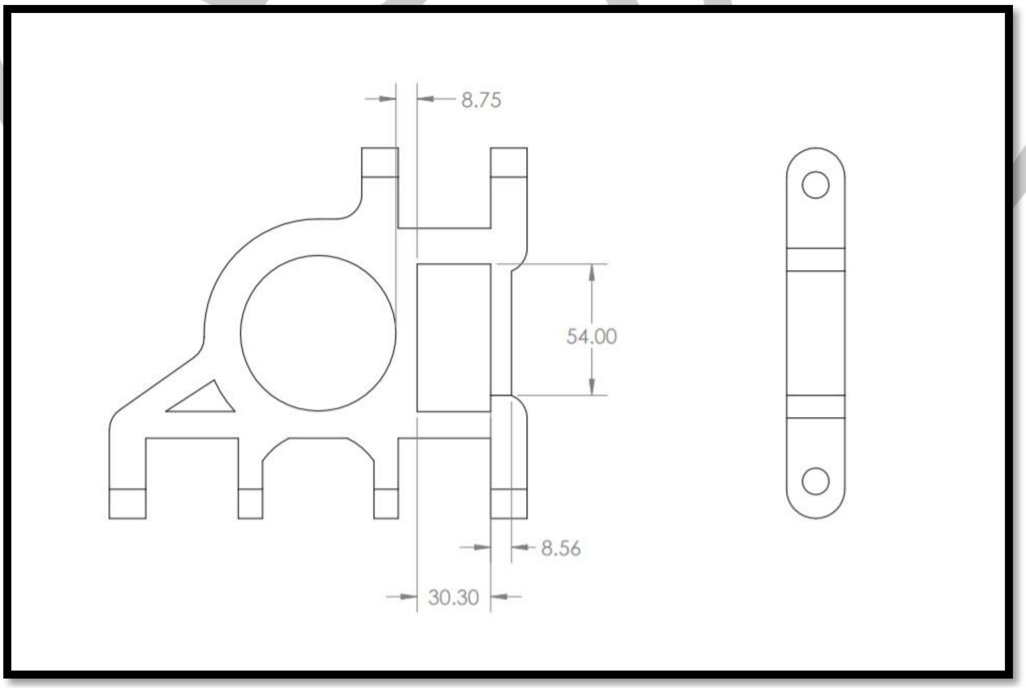
FACTOR OF SAFETY = 1.95

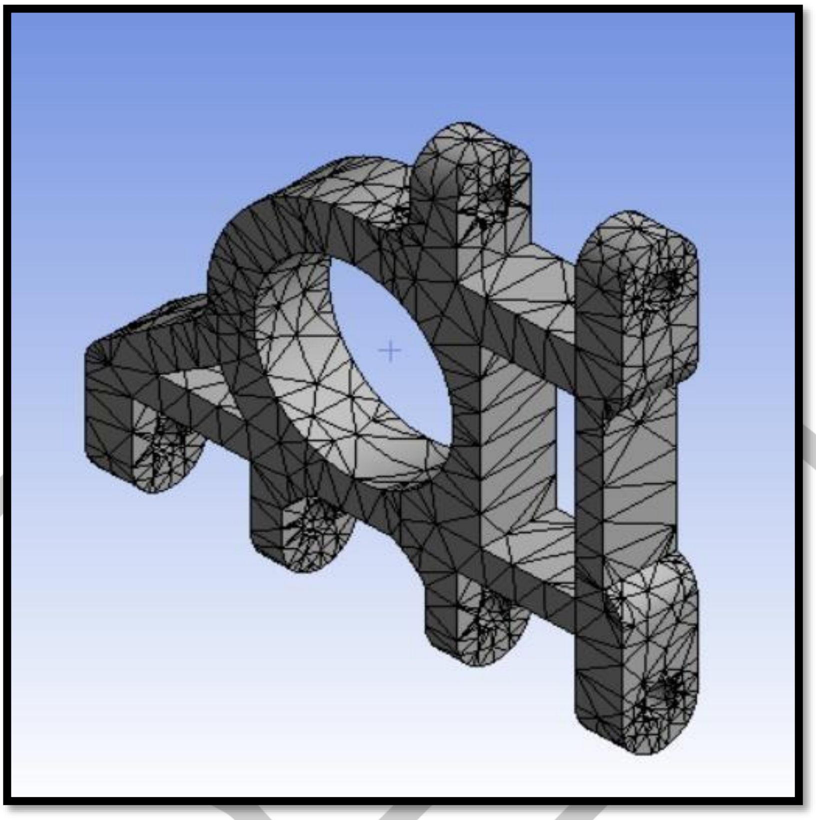
The component withstands the load of 3000 N and we got a satisfactory factor of safety. Further design optimization is done to obtain better results.

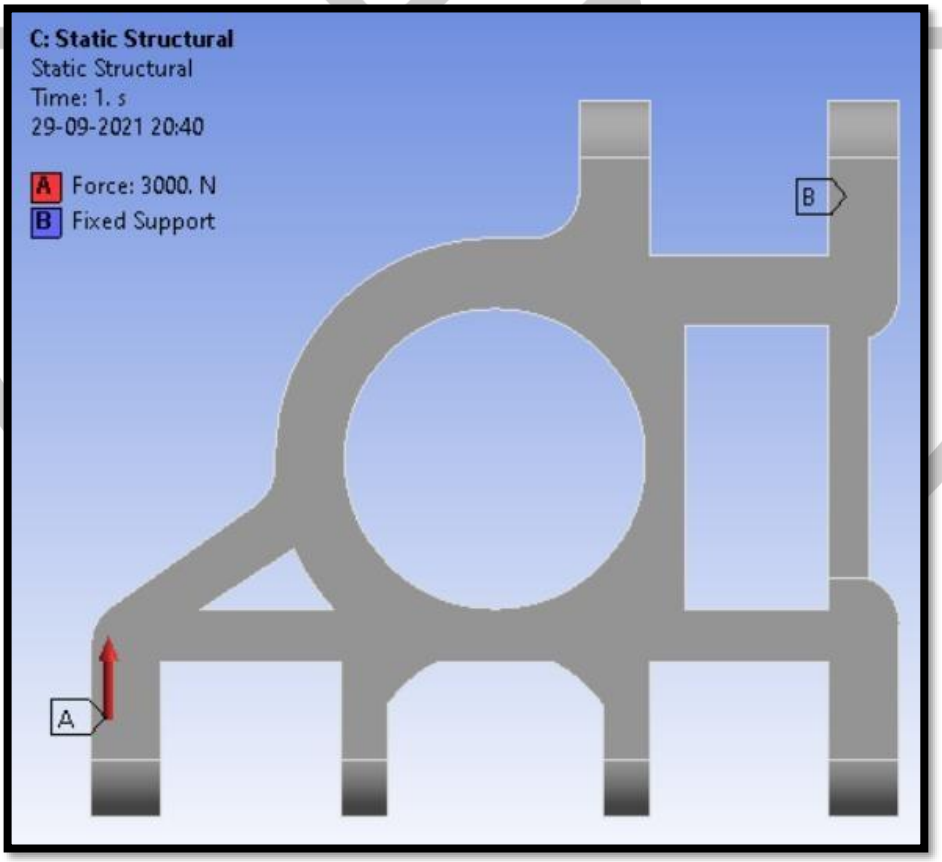
ITERATION-2

We modified the component by removing the material from the body which is near to the hub. Thus, removing the weight from the product.

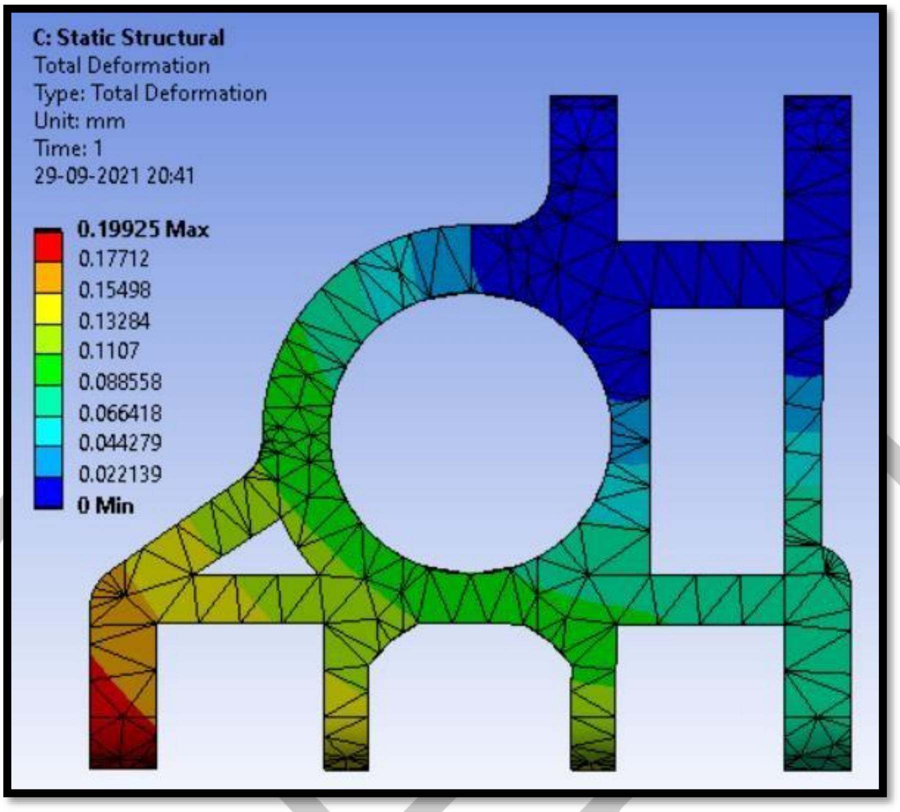


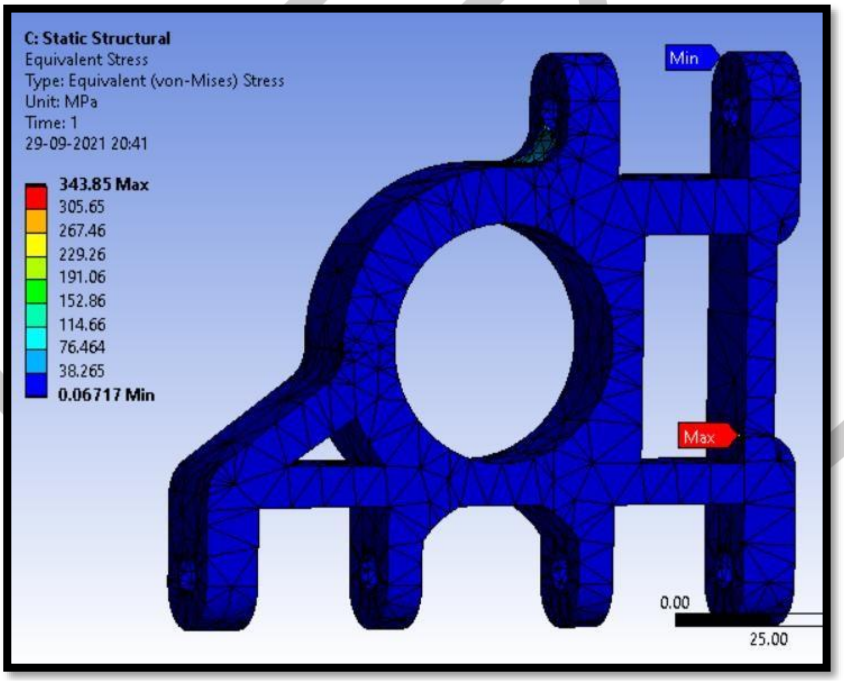





C: Static Structural
Static Structural
Time: 1. s
29-09-2021 20:40
A Force: 3000. N
B Fixed Support
B
A

OUTCOMES:


C: Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
29-09-2021 20:41
0.19925 Max
0.17712
0.15498
0.13284
0.1107
0.088558
0.066418
0.044279
0.022139
0 Min


C: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
29-09-2021 20:41
343.85 Max
305.65
267.46
229.26
191.06
152.86
114.66
76.464
38.265
0.06717 Min
Min
Max
0.00
25.00

RESULT:

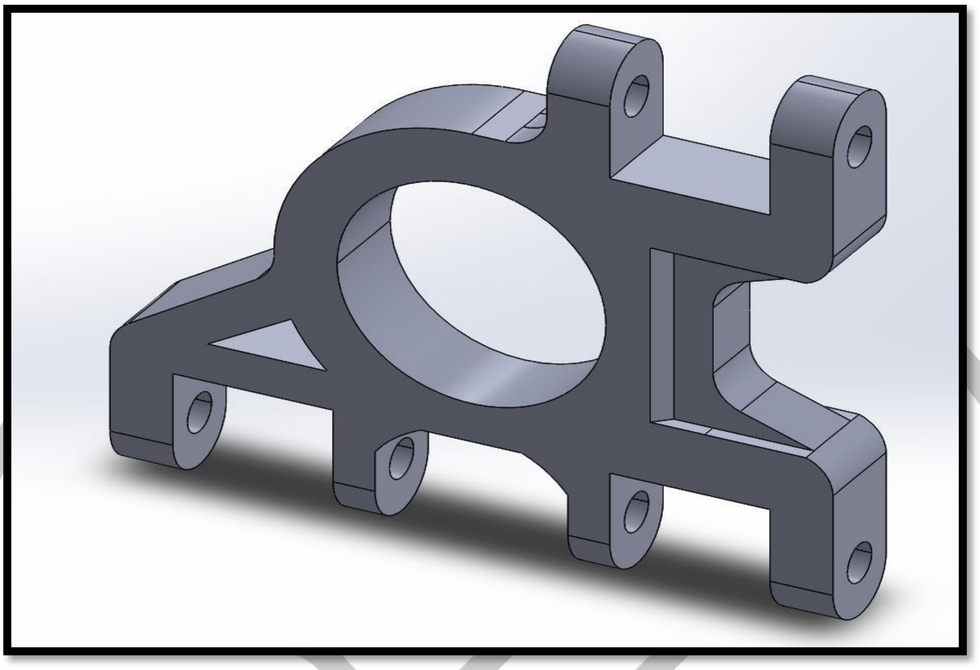
Total deformation (mm)max	Equivalent stress (MPa)
0.199	343.85

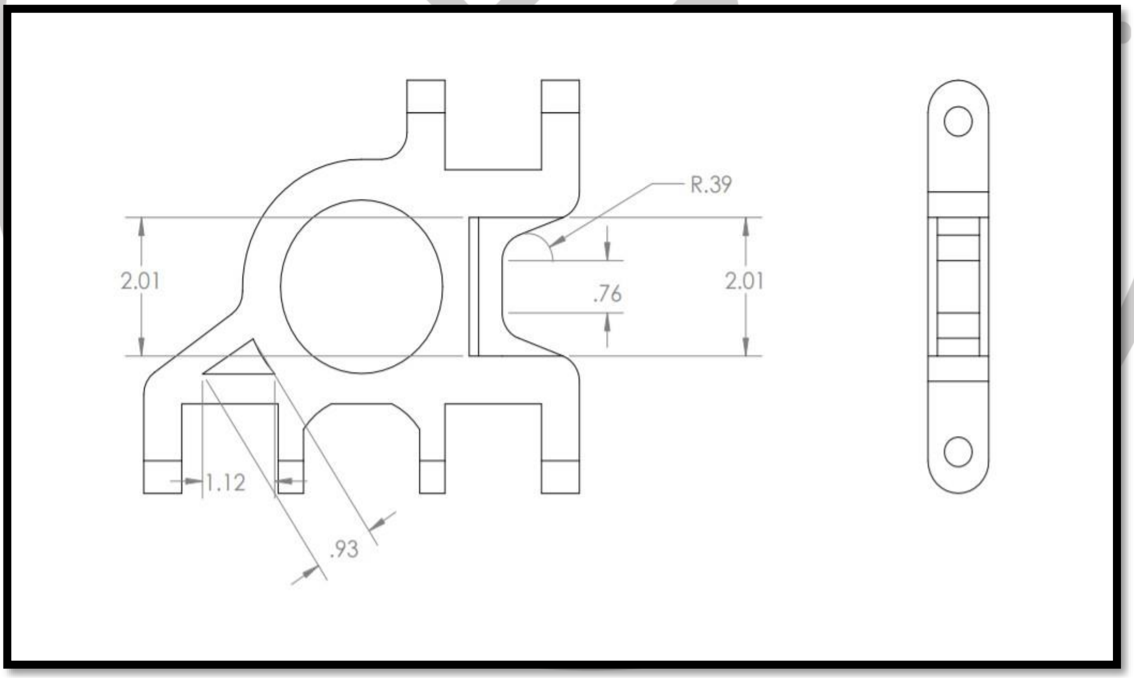
FACTOR OF SAFETY = 1.51

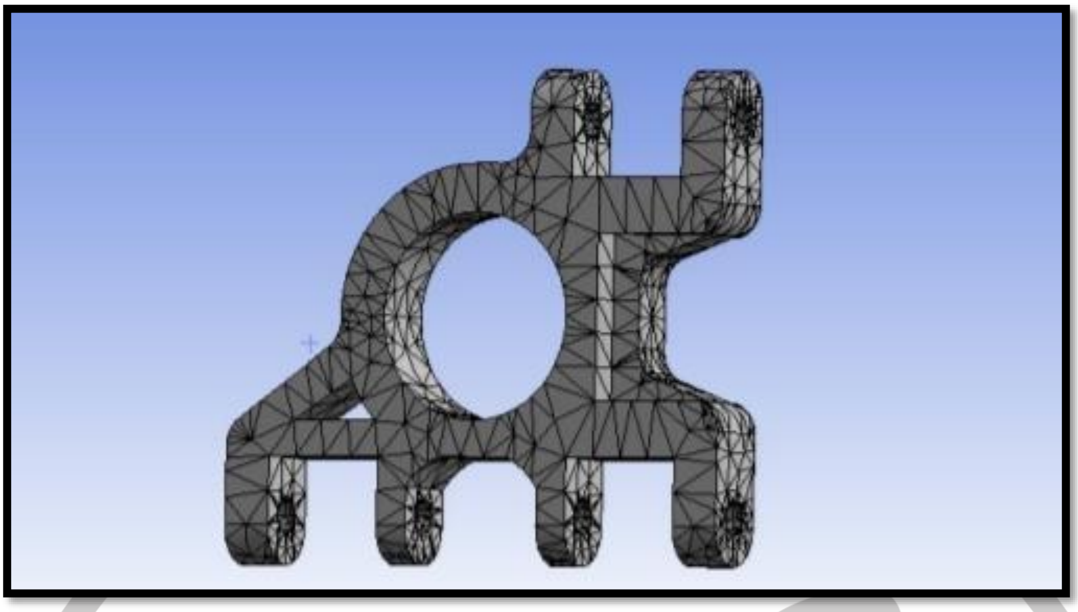
The component withstands the load of 3000 N and we got a satisfactory factor of safety. Further design optimization is done to obtain better results.

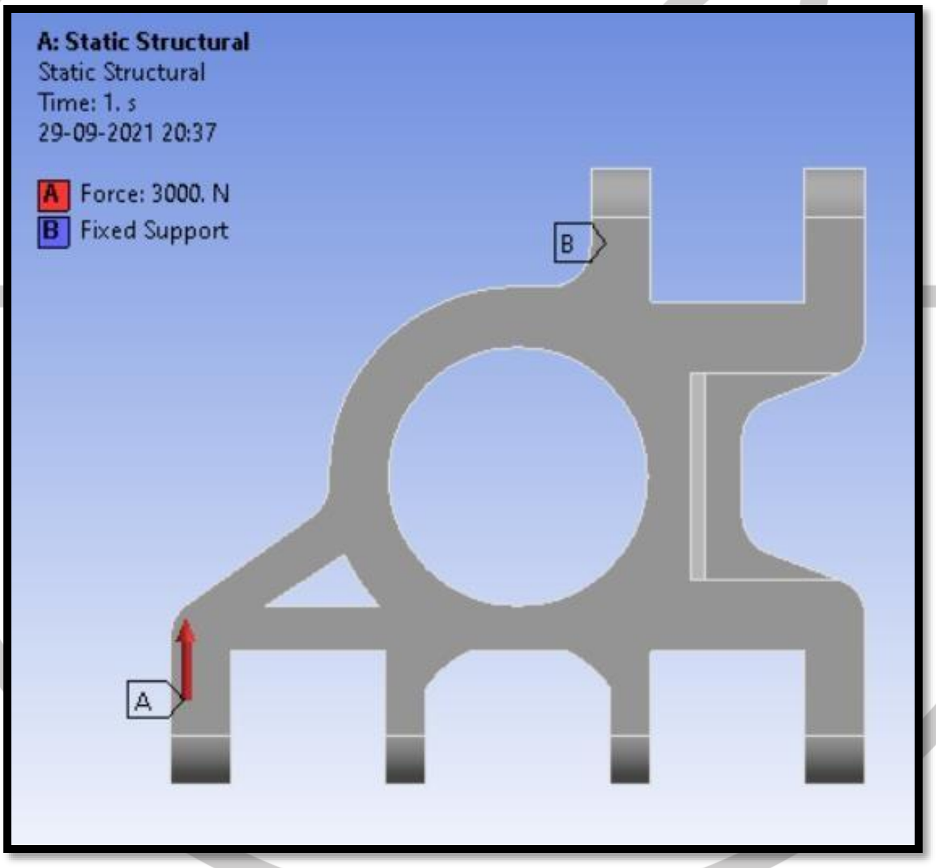
ITERATION-3

We modified the component by removing the material in C-shape from the body which is near to the hub.

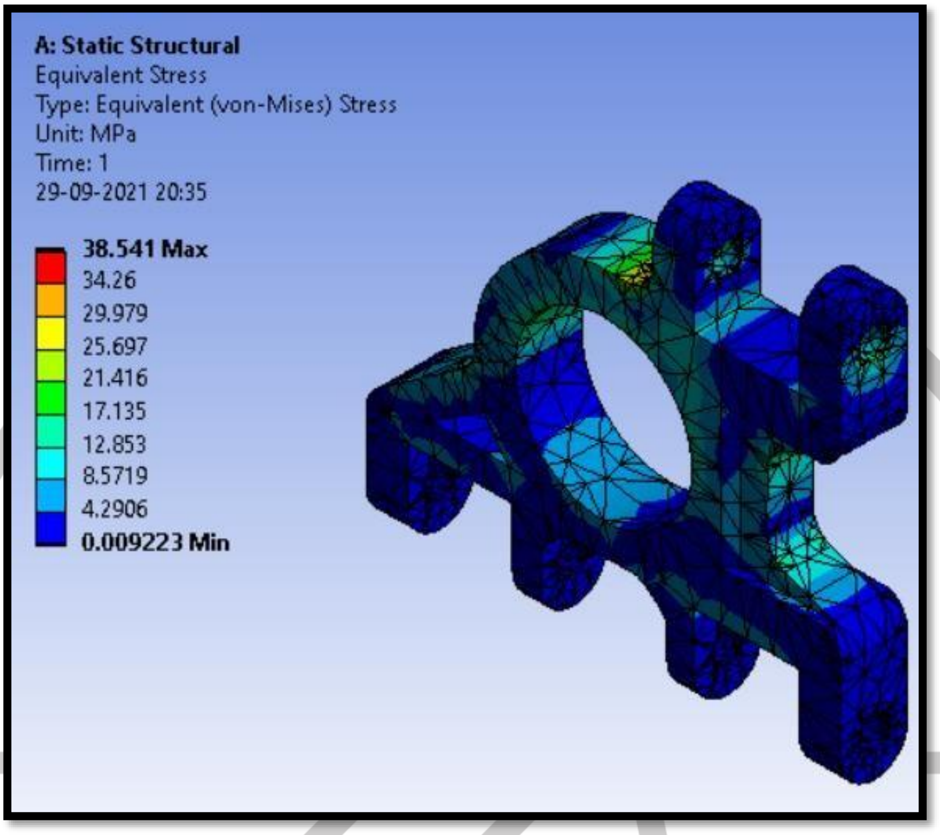


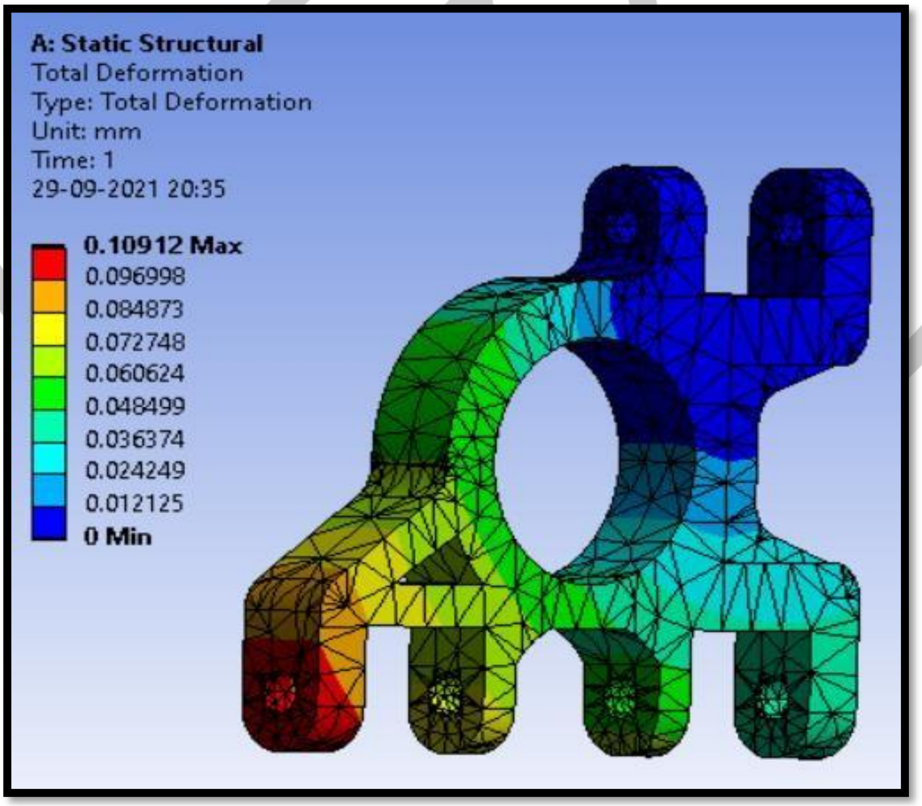





A: Static Structural
Static Structural
Time: 1. s
29-09-2021 20:37
A Force: 3000. N
B Fixed Support
B
A

OUTCOMES:


A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
29-09-2021 20:35
38.541 Max
34.26
29.979
25.697
21.416
17.135
12.853
8.5719
4.2906
0.009223 Min


A: Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
29-09-2021 20:35
0.10912 Max
0.096998
0.084873
0.072748
0.060624
0.048499
0.036374
0.024249
0.012125
0 Min

RESULT:

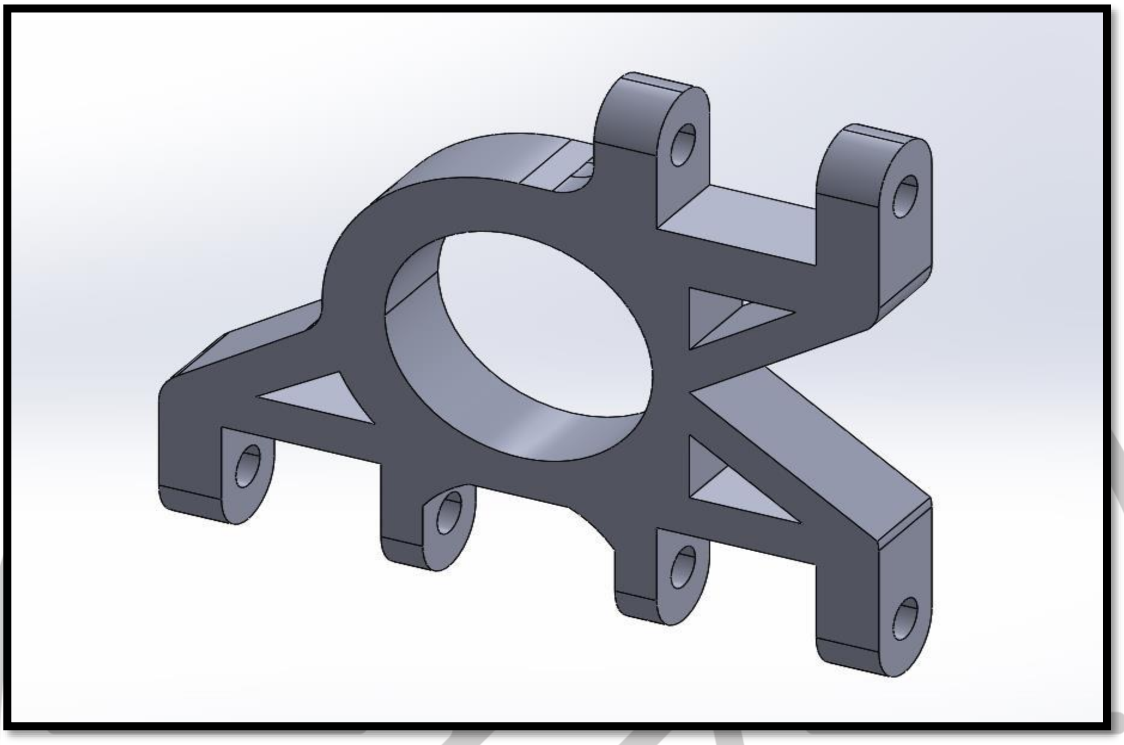
Total deformation (mm)	Equivalent stress (MPa) max
0.102	38.54

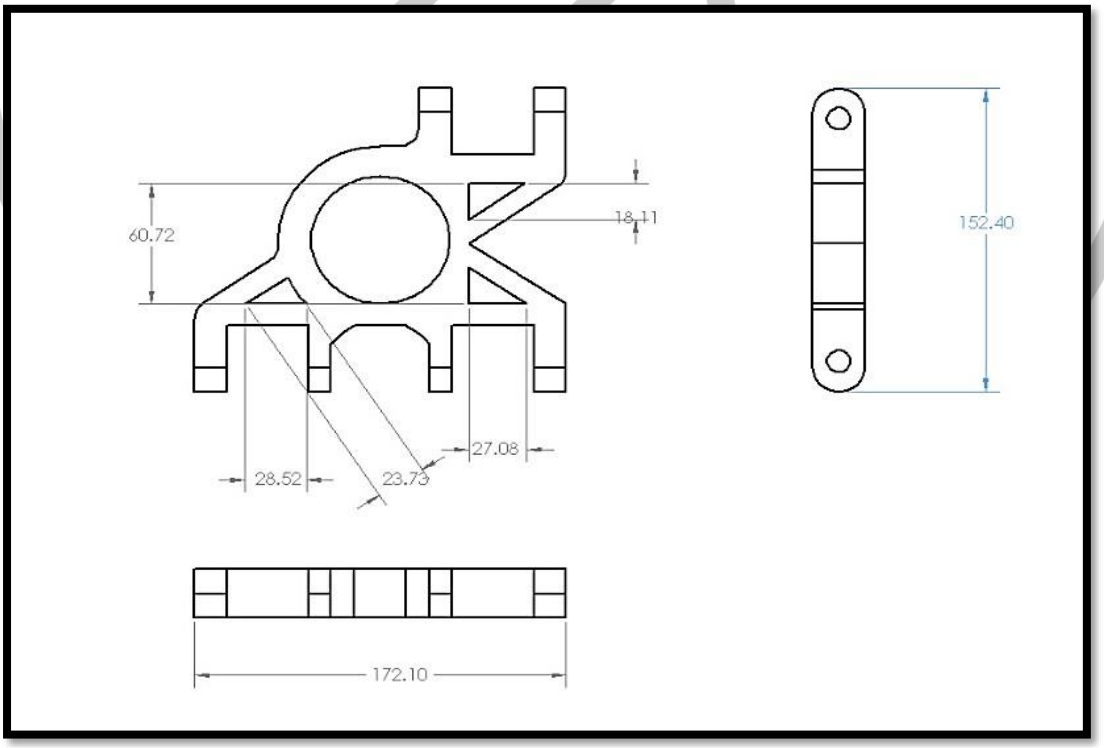
FACTOR OF SAFETY =13.49

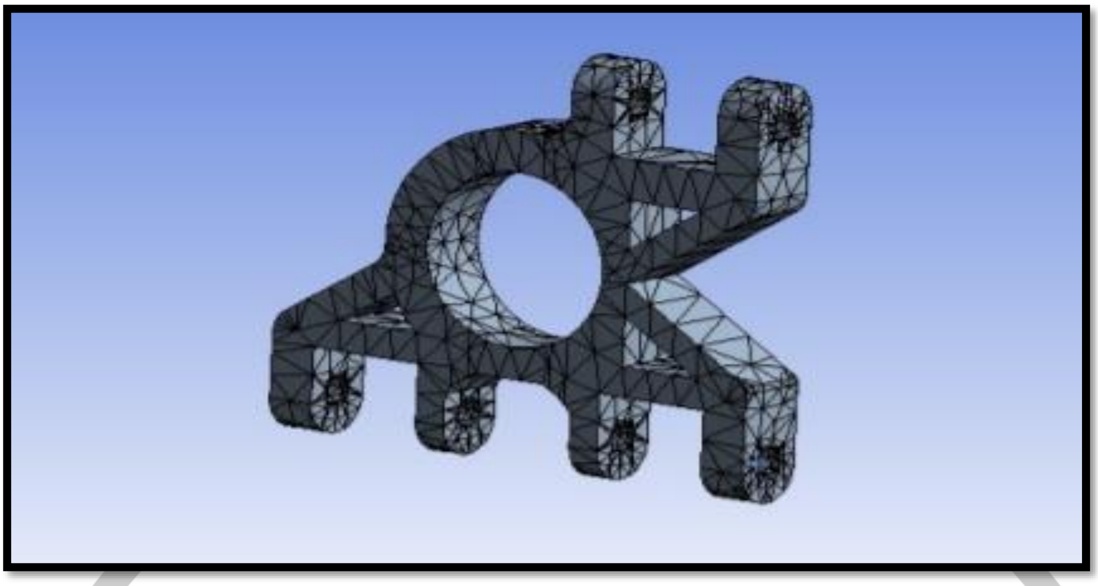
The results obtained showed betterment of the product with shape optimization. Decrease of material consumption with quite similar FOS was obtained.

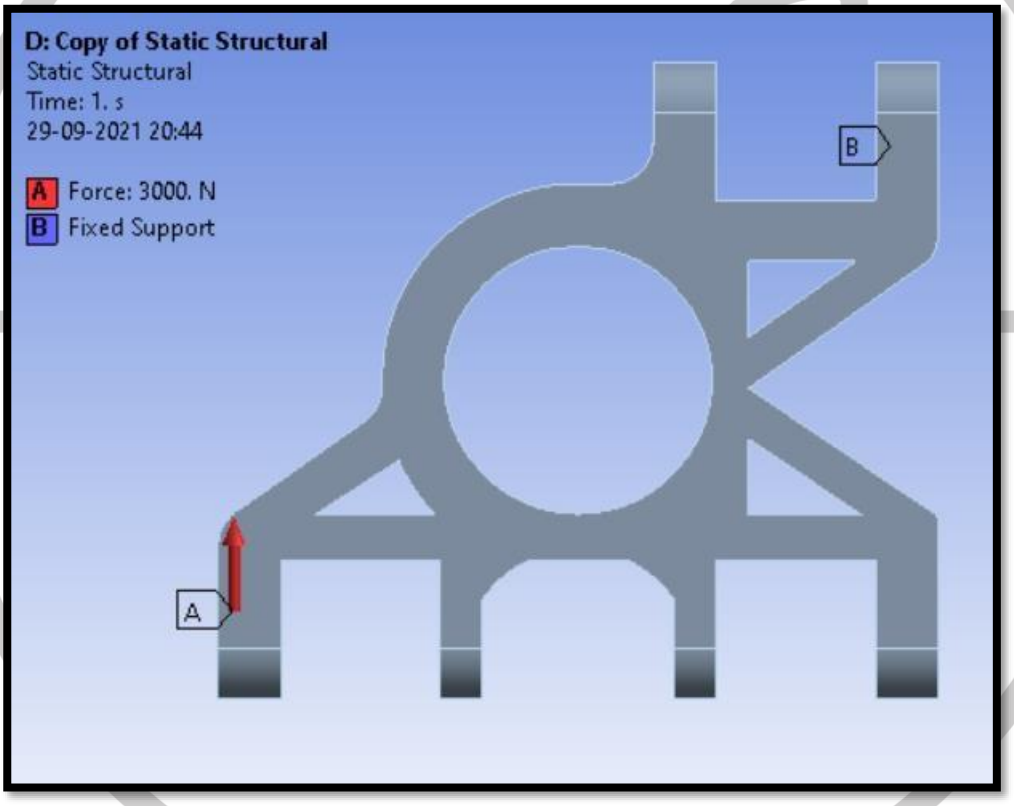
ITERATION-4

Slight changes added in the models design to consider for the edge and corner stress.

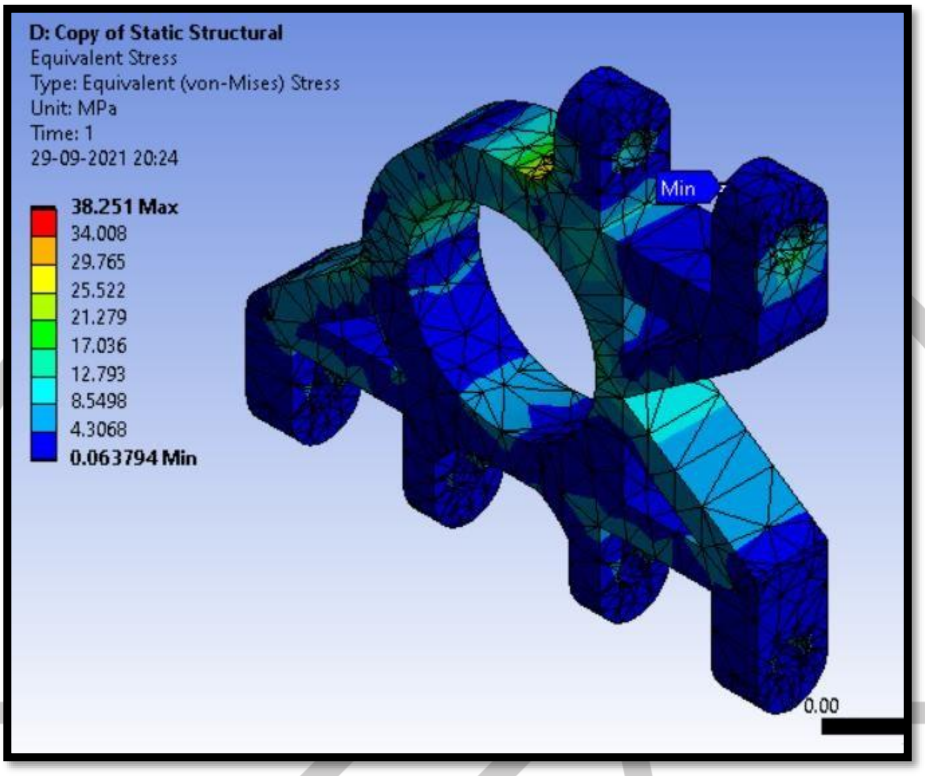


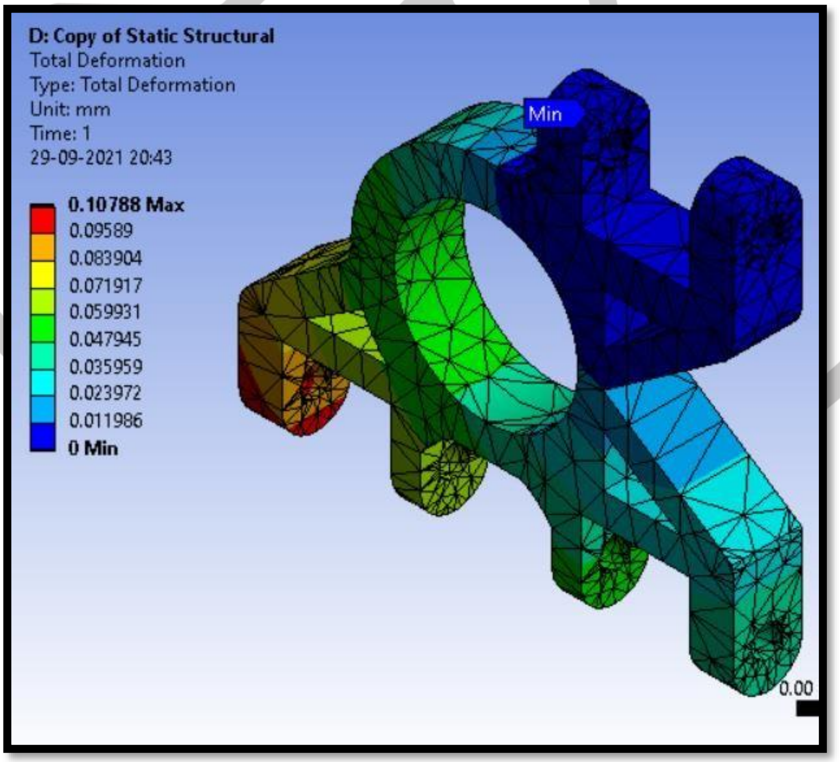





D: Copy of Static Structural
Static Structural
Time: 1. s
29-09-2021 20:44
A Force: 3000. N
B Fixed Support
B
A

OUTCOMES:


D: Copy of Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
29-09-2021 20:24
38.251 Max
34.008
29.765
25.522
21.279
17.036
12.793
8.5498
4.3068
0.063794 Min
Min
0.00


D: Copy of Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
29-09-2021 20:43
0.10788 Max
0.09589
0.083904
0.071917
0.059931
0.047945
0.035959
0.023972
0.011986
0 Min
Min
0.00

In order to obtain even better results the knuckle joint was re-designed after obtaining the results for topology optimization analysis. As triangular shape provides better resistance to stress and has better strength, so we modified the component keeping in mind the triangular shape.

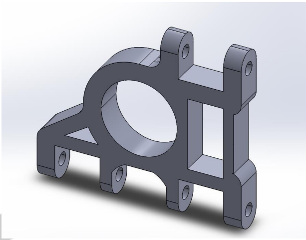
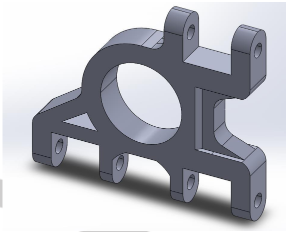
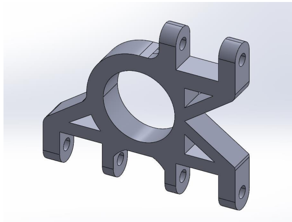
RESULT:

Total deformation (mm)	Equivalent stress (MPa)max
0.1078	38.251

FACTOR OF SAFETY = 13.59

We were able to obtain better results with a good factor of safety of 2.64, also the component can be manufactured at large scale and we were able to optimise the component successfully.

Comparison table:

Shape				
Deformation mm	**0.0806**	**0.199**	**0.109**	**0.1078**
Stress MPa	**266.5**	**343.85**	**38.54**	**38.251**
FoS	**1.95**	**1.51**	**13.49**	**13.59**
Weight gms	**640**	**600**	**631**	**611**

Thus, on the basis of shape, Factor of Safety, deformation, and weight the analysis concluded to the selection of the 4th iteration as the most optimum product.