DESIGN AND ANALYSIS OF DIFFERENTIAL MOUNTS FOR K-4

AN INTRODUCTION TO THE DESIGN

The main motive behind designing the new differential mounts for K-4 was to reduce the weight of the car as much as possible without compromising the strength. A lot of factors had to be taken into account before starting the design process, and the primary factor affecting the design was chassis. Due to the elimination of the differential box from the K-4 chassis, a design had to made to hold the differential assembly accordingly.

Another factor that was kept in mind while designing the mount was chain tensioning. The chain tensioning mechanism in the previous car was quite heavy. So an eccentric differential mount was designed with an inbuilt feature of chain tensioning mechanism, offering elongations/compressions upto length of one chain link i.e approx. 2 cm.

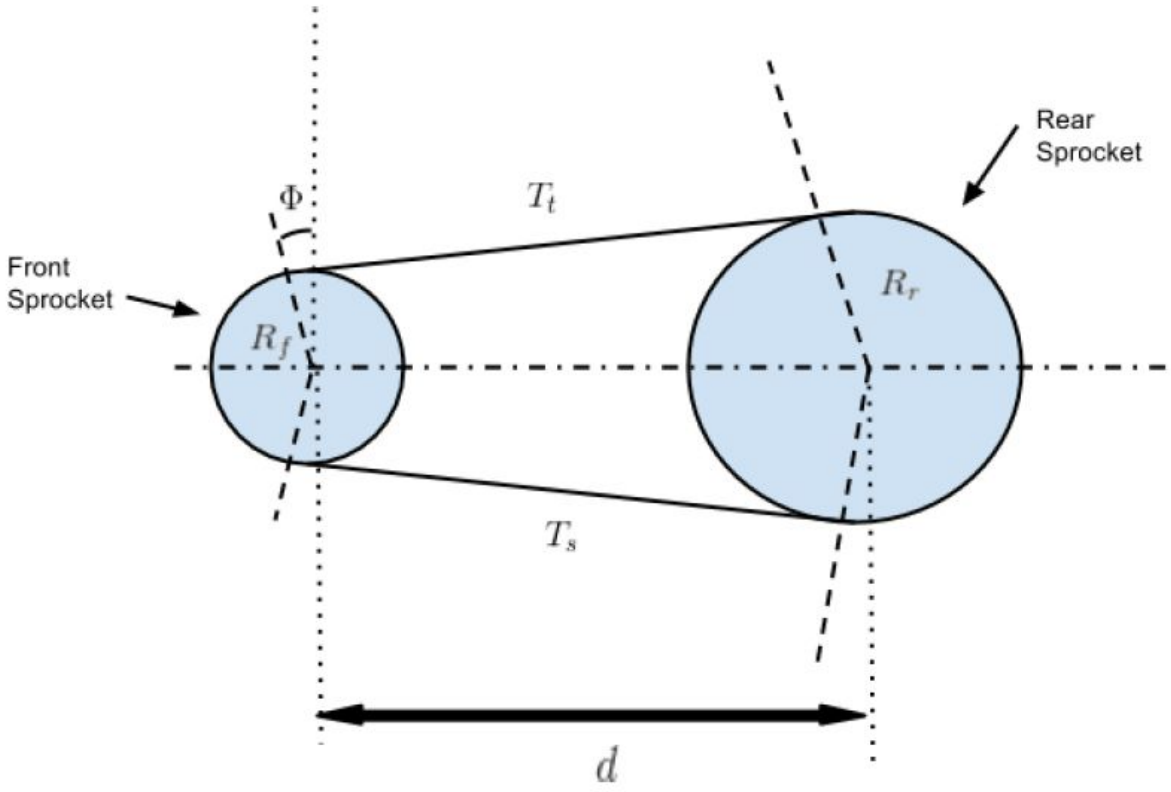
The material used in designing the mount and the eccentric disk was AL-7075 T-6
CAD of the design was made and its FEA analysis was done to test the strength of the mount.

Calculating forces on the differential mount

Maximum tension was calculated in the chain at maximum torque provided by the engine.This tension was the source of force on the differential mount.

Forces

To calculate the forces on the differential mount the chain tension had to be calculated . Max engine torque(after turbocharging) was used to calculate the tension in the chain.



T_S= Tension in the slack side of chain
T_t= Tension in the tight side of chain

Parameters needed to calculate the chain tension

Pitch radius of rear sprocket	R_r	113.8mm
Pitch radius of front sprocket	R_f	35.6mm
Distance between sprockets	d	315mm(approx.)
Front sprocket articulation angle	Θ_f	24deg
Rear sprocket articulation angle	Θ_r	8deg
Front sprocket pressure angle	α_f	26.15deg
Rear sprocket pressure angle	α_r	17.55deg
Front sprocket teeth	n_f	15
Rear sprocket teeth	n_r	45
	Φ	38deg

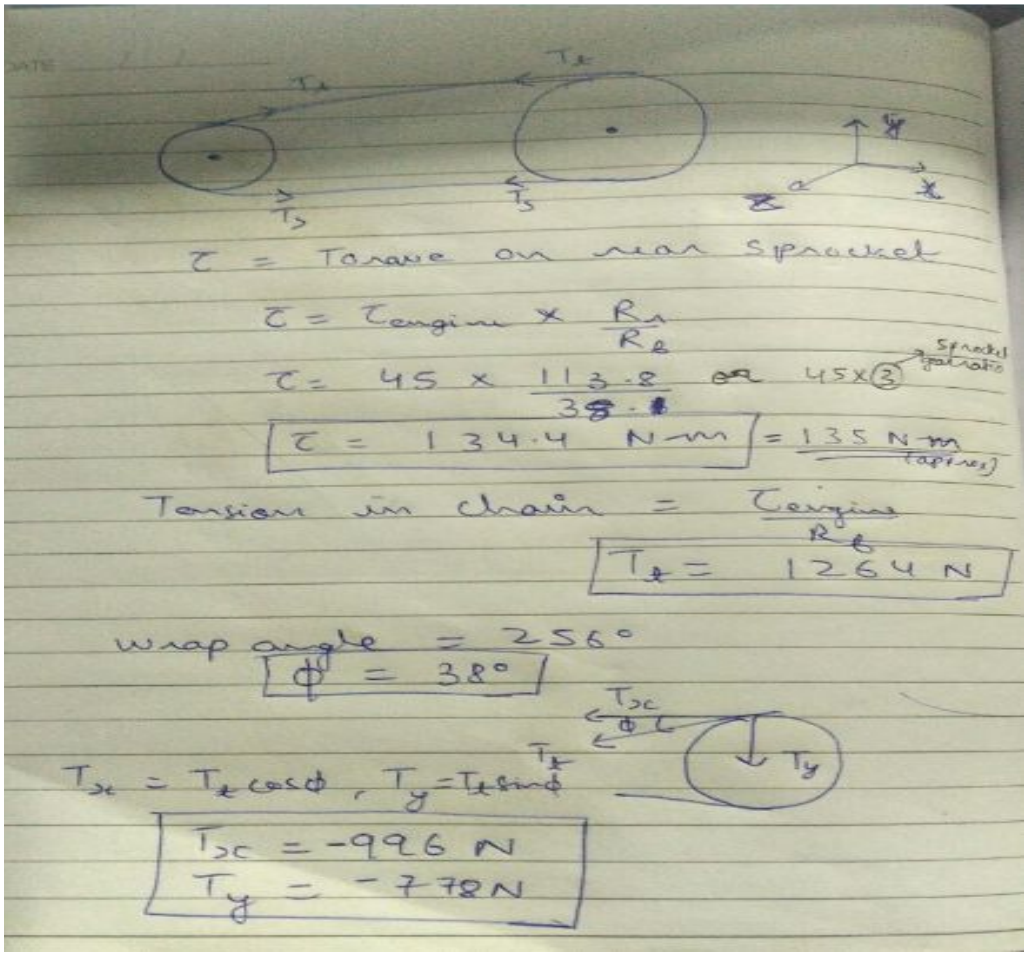
Max torque at front sprocket after turbocharging= 45 N-m (assumption)
Also,

$$T_s = T_t(sin\Theta/sin(\Theta+\alpha))^{n-1}$$

Which is very small as compared to T_t ,hence is taken as zero

Also tension in chain at rear sprocket = tension in chain at front sprocket

Calculations



τ = Torque on rear Sprocket

$\tau = \tau_{engine} \times \frac{R_s}{R_e}$

$\tau = 45 \times \frac{113.8}{38.1}$ or 45×3 (Sprocket ratio)

$\boxed{\tau = 134.4 \text{ N-m}} = \underline{135 \text{ N-m}}$ (approx)

Torsion in chain = $\frac{\tau_{engine}}{R_e}$

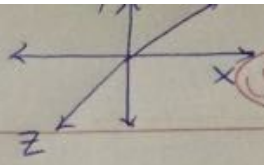
$\boxed{T_t = 1264 \text{ N}}$

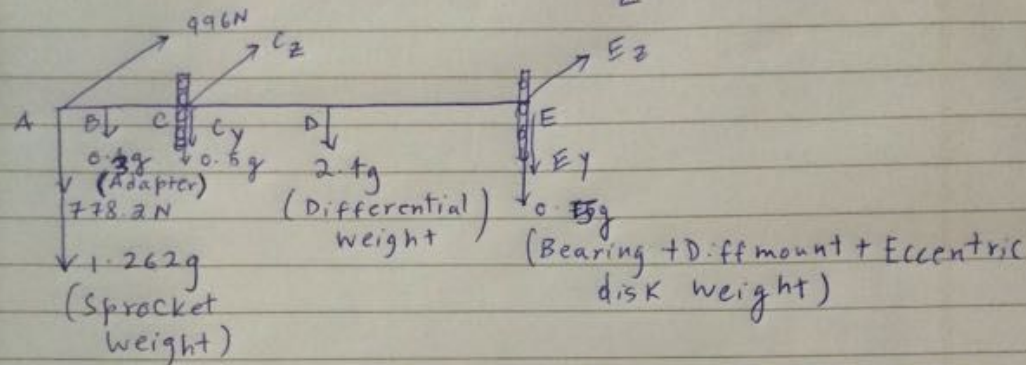
wrap angle = 256°

$\boxed{\phi = 38°}$

$T_{xc} = T_t \cos\phi$, $T_y = T_t \sin\phi$

$\boxed{\begin{aligned} T_{xc} &= -996 \text{ N} \\ T_y &= -778 \text{ N} \end{aligned}}$





$AB = 0.02\,m \quad BC = 0.03\,m \quad CD = 0.06\,m$

$DE = 0.1\,m.$

$$\Sigma F_y = 0.$$

$$C_y + E_y + 2.4g + 0.5g + 0.5g + 0.3g + 778.2 + 1.262g = 0$$

$$\Sigma F_z = 0$$

$$996 + C_z + E_z = 0$$

$\Sigma M_z = 0$ → about 'E'

$$(778.2 + 1.262g) \times 0.21 + 0.3g \times 0.11 + C_y \times 0.16 + 0.5g \times 0.16 + 2.4g \times 0.1 = 0.$$

$$\Rightarrow C_y = -1060.75\ N$$

$\Sigma M_y = 0$ → about 'E'

$$-996 \times 0.21 - C_z \times 0.16 = 0$$

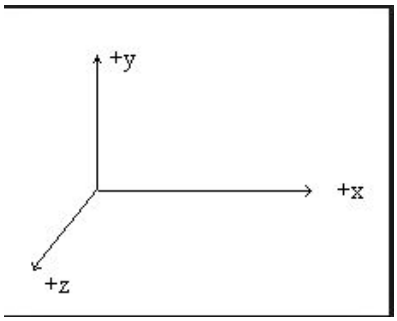
$$C_z = -1307.25$$

$$C = \sqrt{C_y^2 + C_z^2}$$

$$= 1683.47\ N$$

The reactions are higher on the left differential mount and therefore the reactions on the right differential mount were not calculated.

FORCES AND MOMENTS ON THE DIFFERENTIAL MOUNTS ARE



F_x= -1307.25 N **M_x= 0 N-m**

F_Y= -1060.75 N **M_Y=0 N-m**

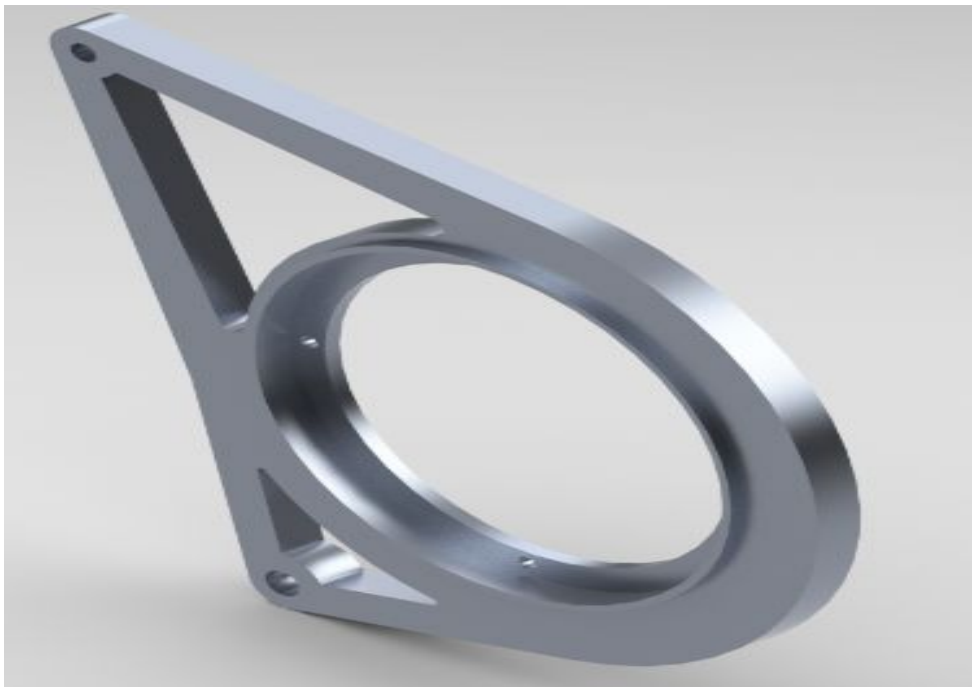
F_Z= 0 N **M_Z= 0 N-m**

CAD AND ITS ANALYSIS

To start with the designing process, CAD was designed and FEA of the CAD was done. Further designs with improvisations were made on the basis of the results of the previous designs.

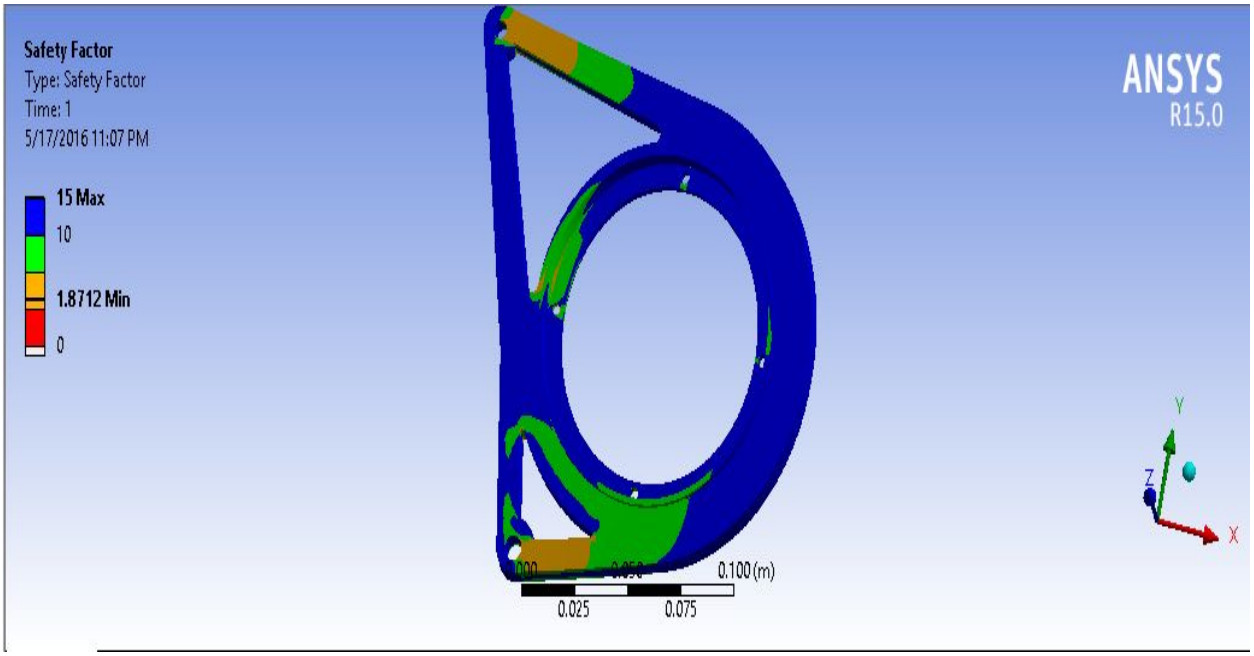
DESIGN 1

Owing to the elimination of the differential box from the chassis of K-4 and the reduction in the height of the chassis tubes where differential was to be mounted, the size and weight of the mount was reduced to a great extent.Below is the CAD of the first design.



FEA analysis of the design was made afterwards, which showed that there was moderate stress concentration at the bottom bolting point(of chassis) . So instead of a M6 hole, M8 hole was made at the point, which gave better results in the next analysis.

Also owing to a very high FOS of the mount coming from the analysis, a lot of weight was shedded from the mount till a required limit. Below is a look of the final analysis of the first design.



Pros

FOS-1.87

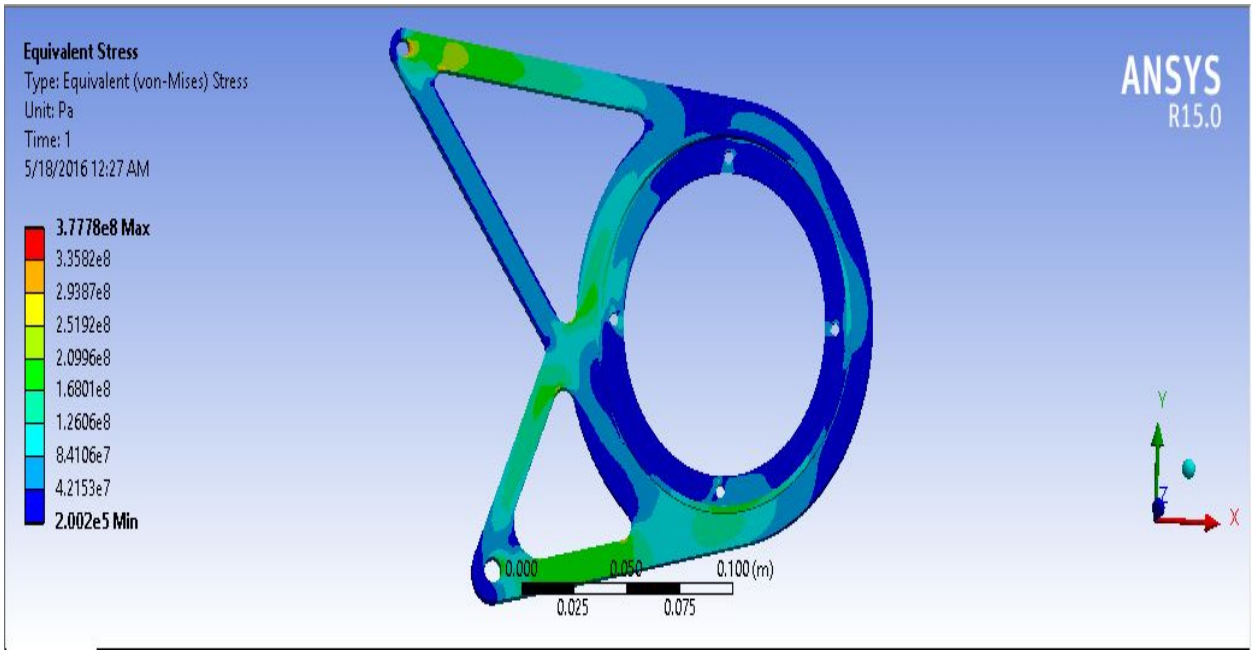
CONS

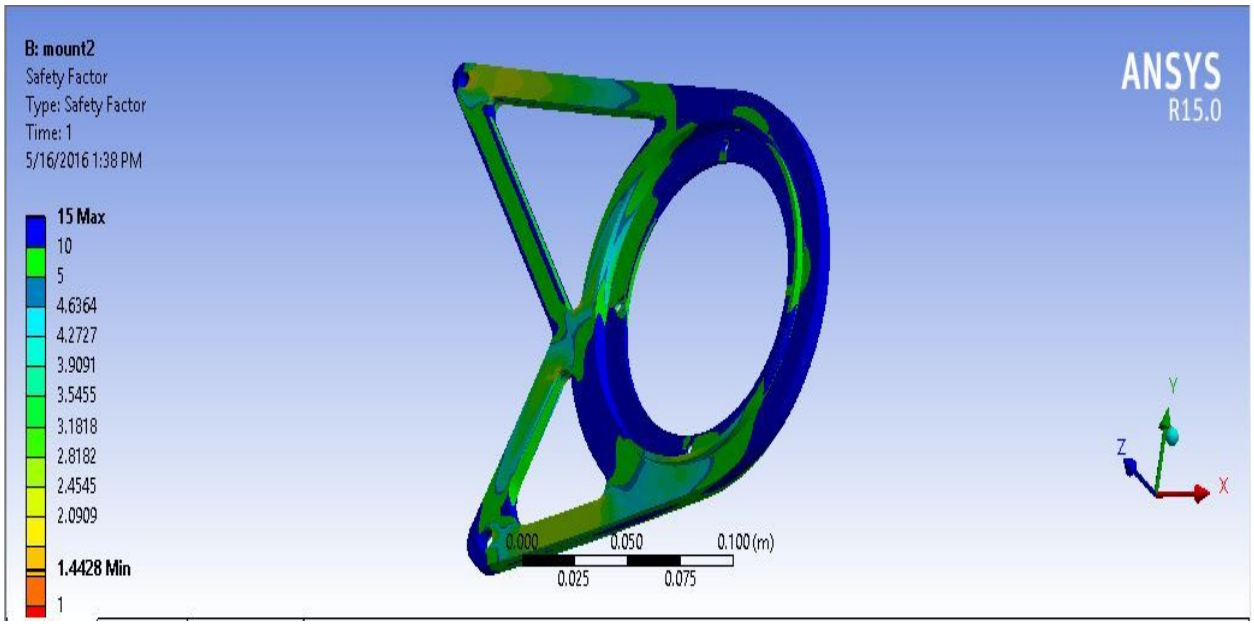
There was a big loophole in the first design as no room was given for the placement of sprocket. The horizontal distance between the two flanges was very less, due to which the sprocket would have interfered with the chassis.

Design 2

Taking into account the mistake done in the previous design, a new design was made to account for the problem. The flanges were made after giving proper space for the sprocket to fit in the place.
This resulted in the increase in the flange length and hence gave rise to a cantilever structure.

FEA analysis of the design was done and a safety factor of **1.44** was observed having a weight of **258** gms i.e 37 gms lesser than the first design.Despite being lightweight the design offers a great deal of strength.





PROS

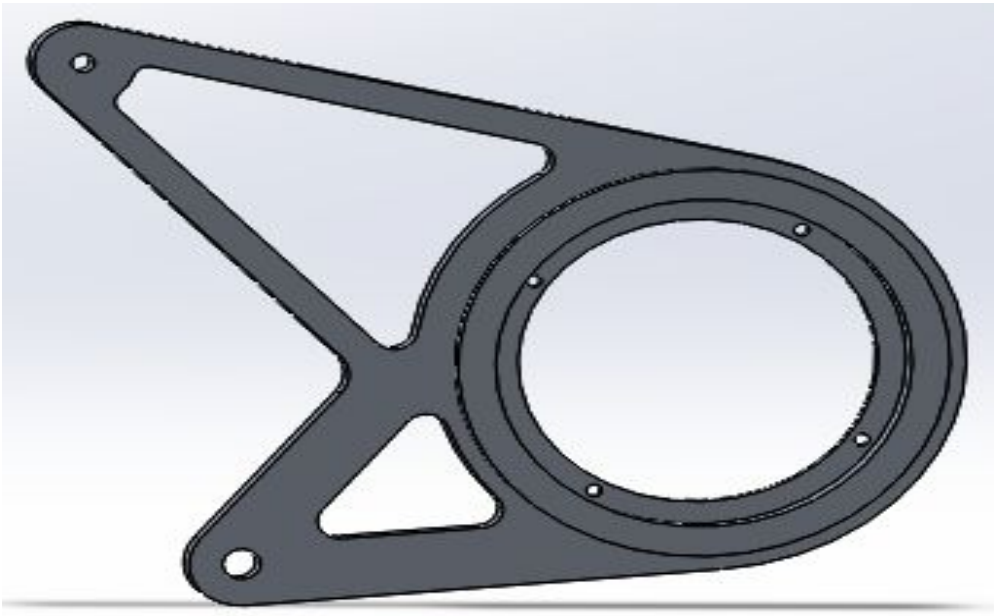
Weight = 258 gms
FOS= 1.44

CONS

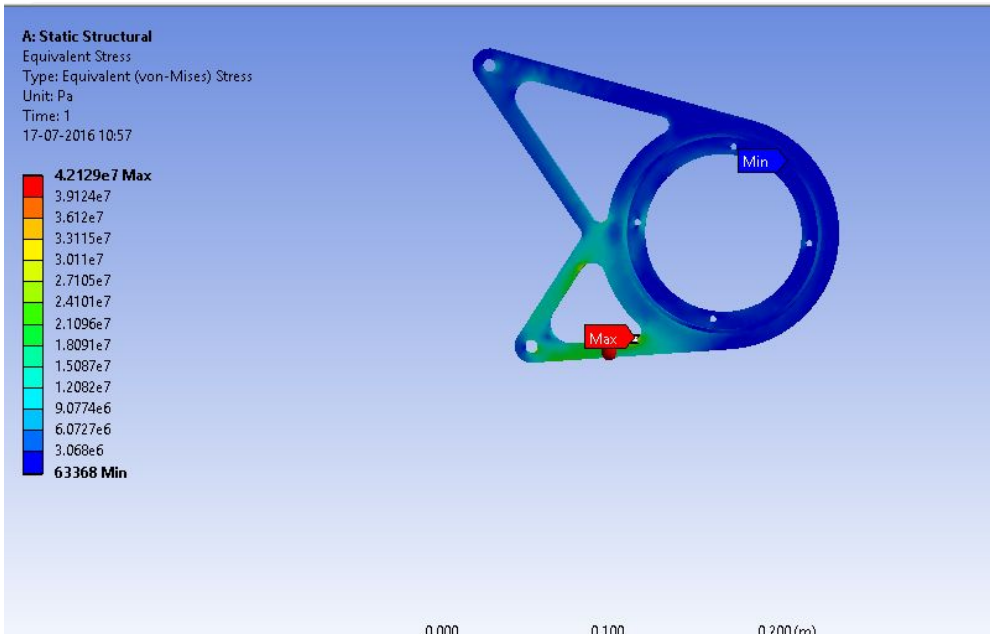
The above design was not able to accommodate the eccentric disk due to large flange area.

PROBLEMS FACED IN DESIGN 2 AND THE CAUSE OF DESIGNS- 3

1. Due to carelessness, the design 2 had to be corrected to accommodate the eccentric disk. Due to overlooking of the design of the disk, the bolting points of the disk had to be made too closer to the edge, which would make the eccentric disk prone to deformation during the machining process. So the design of the mount was changed accordingly.



After correcting the error(design 4)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Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: Pa
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17-07-2016 10:57
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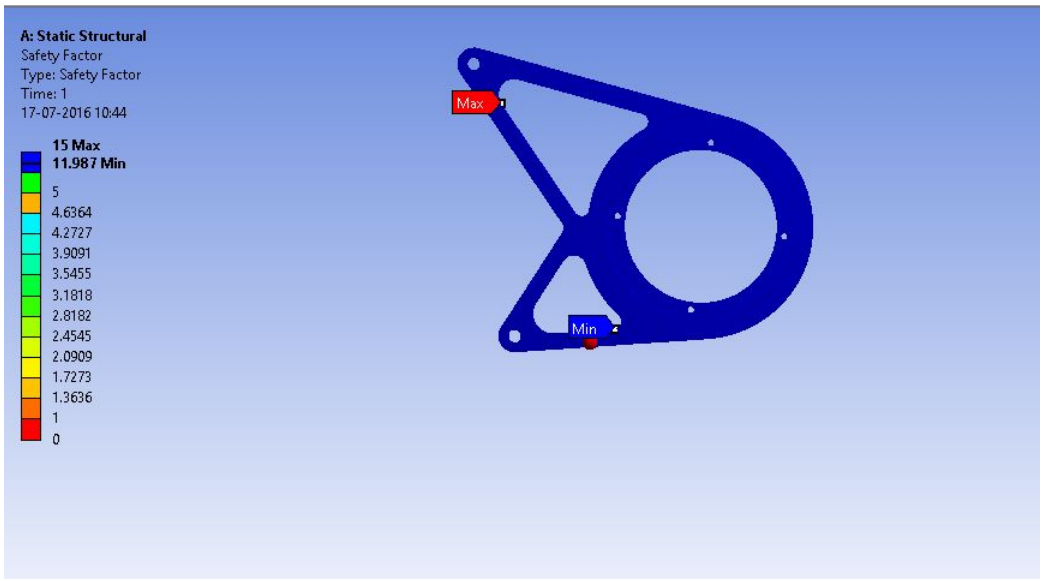
3.612e7
3.3115e7
3.011e7
2.7105e7
2.4101e7
2.1096e7
1.8091e7
1.5087e7
1.2082e7
9.0774e6
6.0727e6
3.068e6
63368 Min
Min
Max
0.000
0.100
0.200 (m)


A: Static Structural
Safety Factor
Type: Safety Factor
Time: 1
17-07-2016 10:44
15 Max
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4.2727
3.9091
3.5455
3.1818
2.8182
2.4545
2.0909
1.7273
1.3636
1
0
Max
Min