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"DESIGN AND MODELLING OF FRONT AND REAR SUSPENSION FOR FORMULA STUDENT VEHICLE"

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Abstract- This project focuses on the design, development, evaluation, and analysis of a suspension system for formula student vehicle..The primary goal suspension system in context of formula vehicle is to provide a proper interface between the driver and vehicle such that a high level of road handling can be realized in a predictable fashion under all expected acceleration and also to prevent the road shocks from being transmitted to the vehicle components and also to safeguard the reside from road shocks and to preserve the stability of the vehicle in pitching or rolling.

Generally, for formula vehicles coil springs are used as suspension system. By using push pull rod system we can lower COG of the vehicle which in turns increase the vehicle performance. Here the modelling of spring, damper, rocker arm, anti roll bar and push rod was done using CATIA software. And design of the suspension system is done in adams software.

Based on the different parameter and iteration we have decided to go with mild steel. According to design of the vehicle we decided to go with push rod suspension system.

Key words: spring, damper, rocker arm, push rod, Adams, catia.

1. INTRODUCTION

Suspension system

The suspension is the system of tires, tire air, spring shock absorber and linkage that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems must support both road holding/handling and ride quality.

Objectives of the suspension system

To prevent the road shocks from being transmitted to the vehicle components. To safeguard the reside from road shocks and To preserve the stability of the vehicle in pitching or rolling, while in motions

Working of the suspension system

The suspension control ARM or links allow wheel movement independent of the body. This provides a mechanism to isolate the body from the road bumps. The springs manipulate the frequency of road disturbances and try to bring them into a more manageable band. They also provide damping through friction (spring ends and the seat) and own hysteresis. The damper dissipates the energy of the dynamic load comin through the road bumps. Together, they try to eliminate the effects of road undulations onthe ride as well as stability of the vehicle.

Types of the suspension system

There are mainly three types of suspension systems present to an automobile. It depends on the type of vehicle and the weight and performance of the vehicle.

- Dependent suspension system
- Independent suspension system
- Semi-independent suspension system

Springs

There are different types of springs present in an automobile suspension system

Helical spring

Spring is an elastic object that stores mechanical energy. Springs are typically made of spring steel. There are many spring designs. In everyday use, the term often refers to coil springs.

CALCULATION

For the different types of load transfer on the suspension system we have use the Matlab software to get the desire output .In the matlab we have selected certain input parameter based on the our vehicle design and the require coding was done in the matlab after the calculation in the software we get the certain output parameter of the suspension system.[1]

Front suspension

	A	B
1	Inputs	
2	MOTION RATIO	1
3	WHEEL TRAVEL(mm)	25
4	SPRING RATE(N/mm)	10
5	Deceleration (in g's)	1.5
6	Mass of vehicle(kg)	260
7	CG height(m)	0.254
8	Wheel Base (m)	1.524
9	Front track width(m)	1.1684
10	Rear track width(m)	1.1938
11	mass ratio on front	0.45
12	mass ratio on rear	0.55
13	Cornering acceleration(in g's)	0.89
14	wheel radius(m)	0.205
15	Modulus of elasticity (E) in Pa	4.81E+08
16		

Front_Suspension	FSFU	FSRU	FSUO	FSFL	FSRL	FSLO	PRUP	PRLP	wheel center
x	0.04	0.28	0.166	0.4	0.28	0.15	0.16	0.16	0.16
y	-0.29	-0.29	-0.552	-0.25	-0.25	-0.574	-0.38	-0.51	-0.609
z	0.386	0.36	0.308	0.21	0.21	0.21	0.22	0.42	0.31

Input parameter for front suspension

```
E: ▸ matlab
Command Window
longitudinal load transfer=637.65N
lateral load transfer=345.44N
Mass_at_front_after_transfer =182.00N
The forces acting on wishbones:
 FSFU=1924.17N
 FSRU=-767.93N
 FSFL=-966.42N
 FSRL=-1226.54N
 PR=1056.85N
Enter required internal diameter of Tube(in meters)=8
The outer diameter =16.00N
>>
```

Output of front suspension

Rear suspension

Inputs	
MOTION RATIO	1
WHEEL TRAVEL(mm)	25
SPRING RATE(N/mm)	10
Deceleration (in g's)	0.5
Mass of vehicle(kg)	260
CG height(m)	0.254
Wheel Base (m)	1.524
Front track width(m)	1.1684
Rear track width(m)	1.1938
mass ratio on front	0.45
mass ratio on rear	0.55
Cornering acceleration(in g's)	0.89
wheel radius(m)	0.205

REAR_SUSPENSION	RSFU	RSRU	RSUO	RSFL	RSRL	RSLO	PRUP	PRLP	wheel center
x	1.386	1.693	1.693	1.386	1.672	1.672	1.645	1.645	1.684
y	-0.226	-0.226	-0.54	-0.2	-0.2	-0.54	-0.29	-0.49	-0.584
z	0.344	0.36	0.39	0.21	0.21	0.21	0.536	0.217	0.31
	1	4	7	10	13	16	19	22	25
	2	5	8	11	14	17	20	23	26
	3	6	9	12	15	18	21	24	27

Input parameter of rear suspension

Note: The input parameter was taking by considering the Formula Bharat rule book 2020.

```
>> Rear_wishbones

Longitudinal_load_transfer =

  212.5500


Mass_transfer =

   21.6667


Mass_at_rear_after_transfer =

  164.6667


Lateral_load_transfer =

  305.8911

The forces acting on wishbones:
  RSFU=585.91N
 RSRU=1616.97N
 RSFL=-726.77N
 RSRL=1390.12N
 PRU=-986.33N
Rear_wishbones
```

Output of rear suspension

Modelling

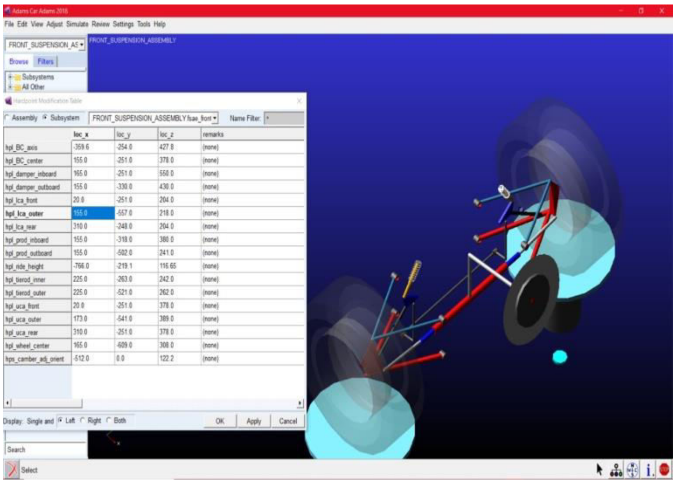
LOCATION OF SUSPENSION POINTS

From the different iteration in the adams software we have choosing given parameter for our vehicle.

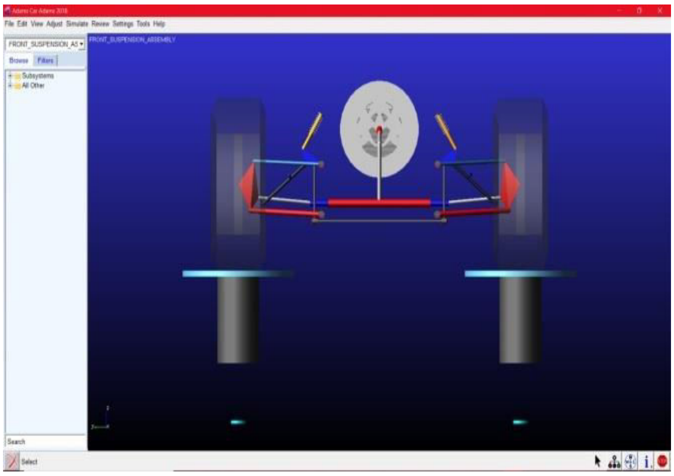
Parameter	Front	Rear
Camber	-1.5	0
Caster	5	5
King pin inclination	4	0
Scrub radius	28mm	60
Toe	0	0
Track width	1168	1193
Wheel base	11524	

Table 1 Parameter of the suspension system

FRONT SUSPENSION

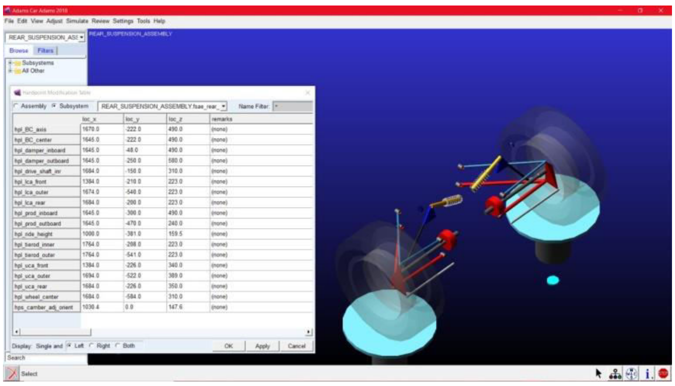


Isometric view of front suspension

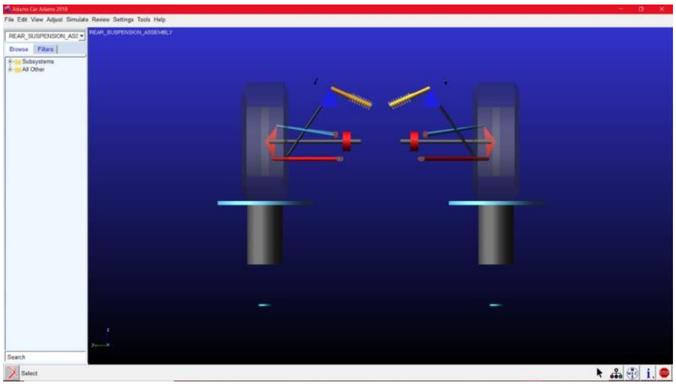


Front view of suspension

REAR SUSPENSION

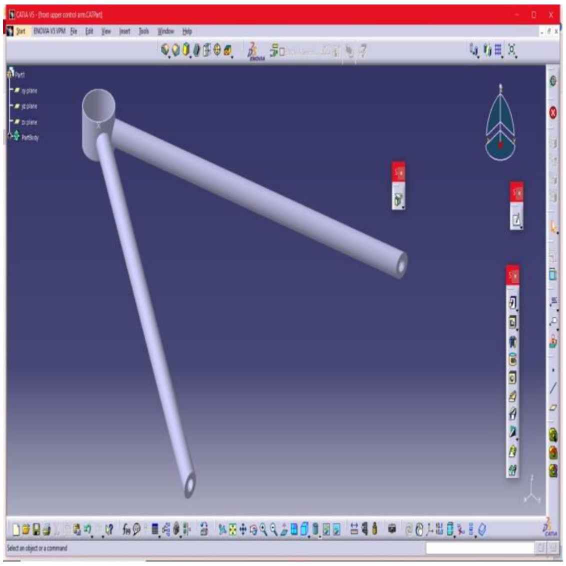


Isometric view of rear suspension

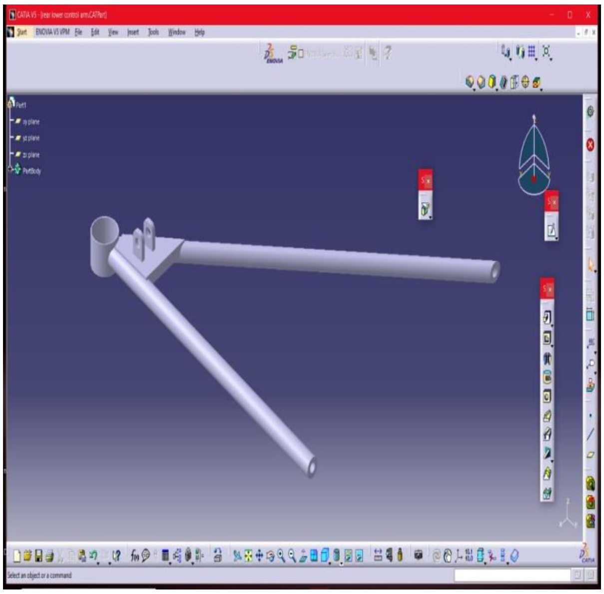


Front view of rear suspension

MODELLING OF A-ARM.

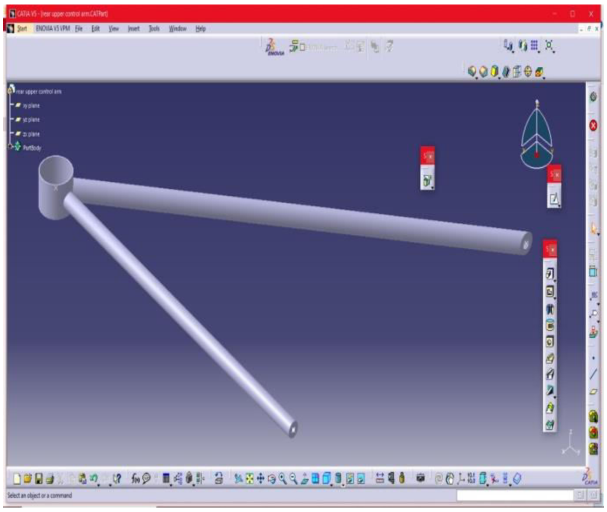


Design of front A-ARM of upper

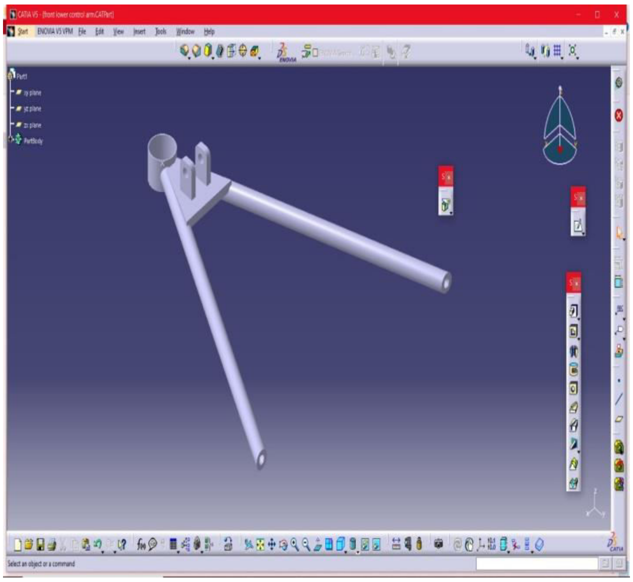


Design of front A-ARM of lower

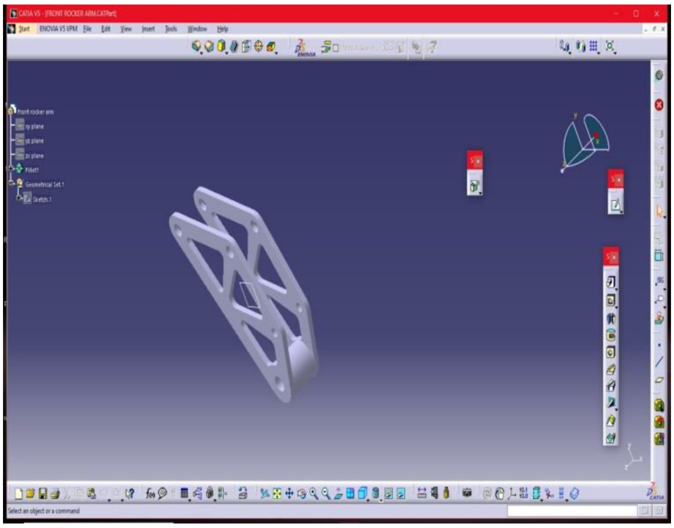
2 REAR A-ARM



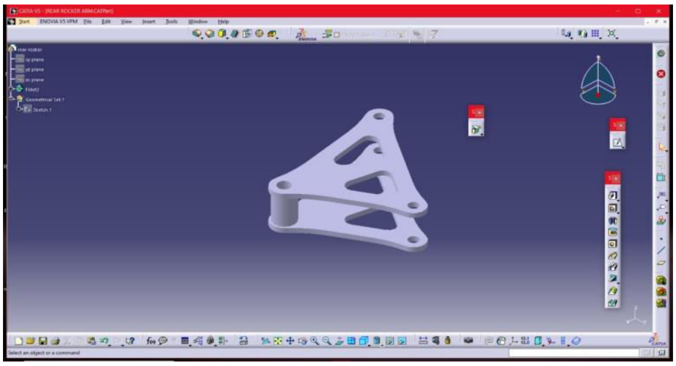
Design of rear A-ARM of upper



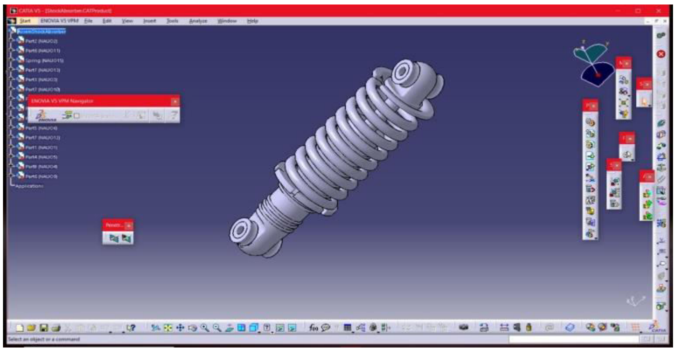
Design of rear A-ARM of lower



Design of front rocker arm



Design of rear rocker arm



Design of damper

SELECTION OF MATERIAL

A-ARM play an important role in the suspension system, as it acts as a link between the chassis and the tyre. So the material selection plays an important role in the suspension geometry. From the data available on the internet and based on the formula bharat rule book 2020 we decided to go with the mild steel material. Since it is easily available and within the budget also .Below table is comparison between different type of material.

Table 2 Selection of material

Properties	MILD STEEL	ALUMINIUM	AISI 4130	AISI 1020	CARBON FIBER
YOUNGS MODULUS(GPA)	210	70	205	200	228
DENSITY(KG/M^3)	7850	2680	7850	7870	2000
POISSON'S RATIO	0.3	0.33	0.29	0.29	0.2
YEILD STRENGTH (MPA)	250	214	435	295	725
ULTIMATE STRENGTH (MPA)	360	262	670	395	1400

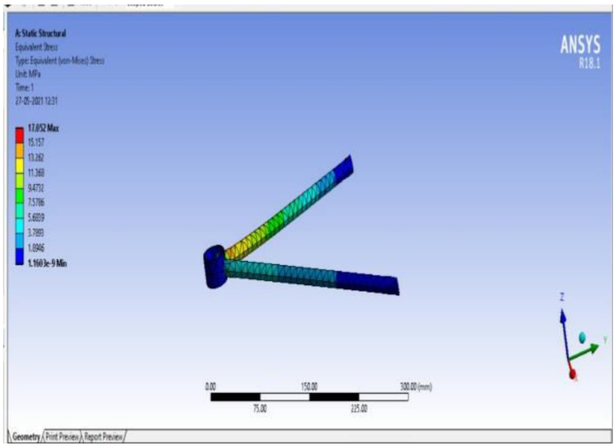
ANALYSIS

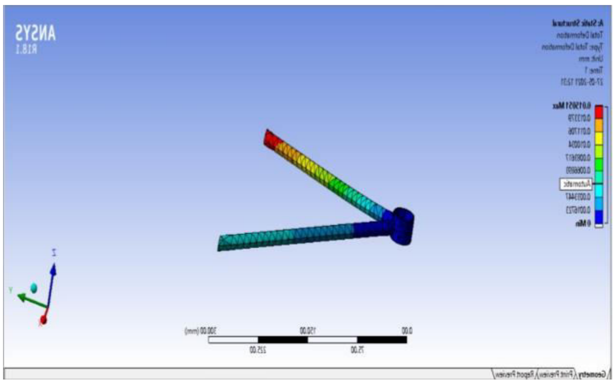
Steps involved

1. Defining the Engineering Data
2. Importing the developed Spring and anti roll bar in STEP format file under geometry.
3. In Model analysis,
   a) Generate the mesh
   b) Applying a fixed support
   c) Apply force
   d) Insert Total Deformation
   e) Evaluating the Result
4. In Static Structural analysis, apply the boundary conditions (fixed base and fixed vertices), applying gradually increasing loads and evaluating the results.

RESULT

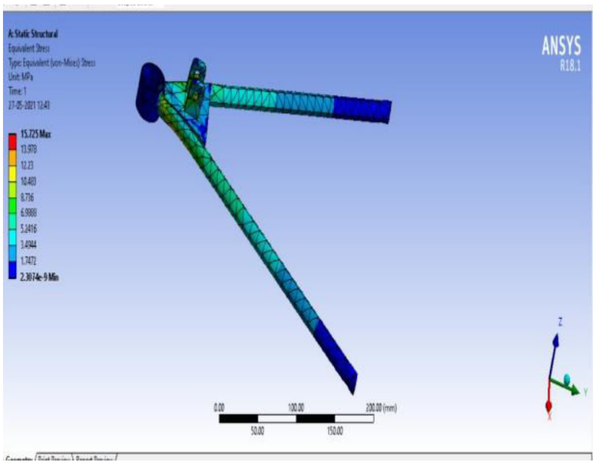
FRONT UPPER A–ARM

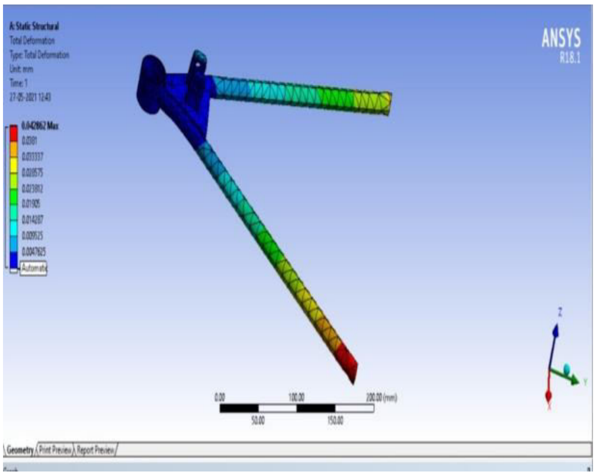




Equivalent stress and total deformation front upper A-ARM

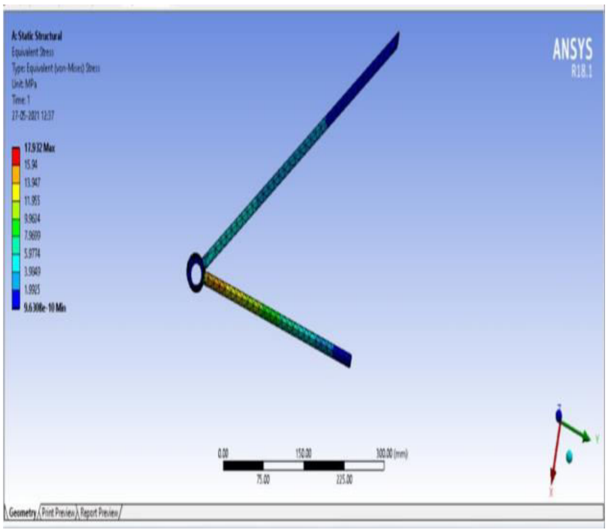
FRONT LOWER A –ARM

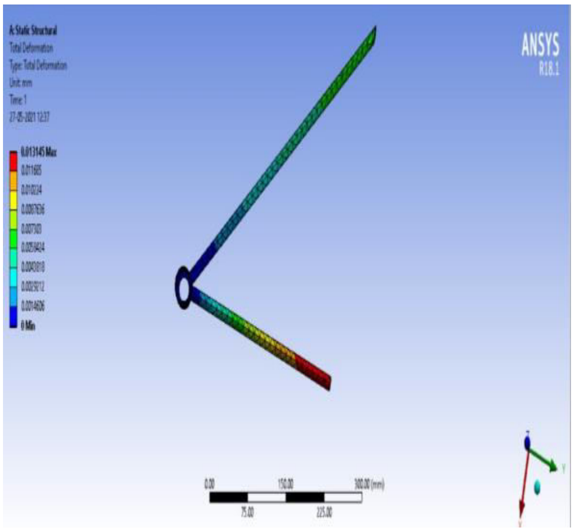




4 Equivalent stress and total deformation front lower A-ARM

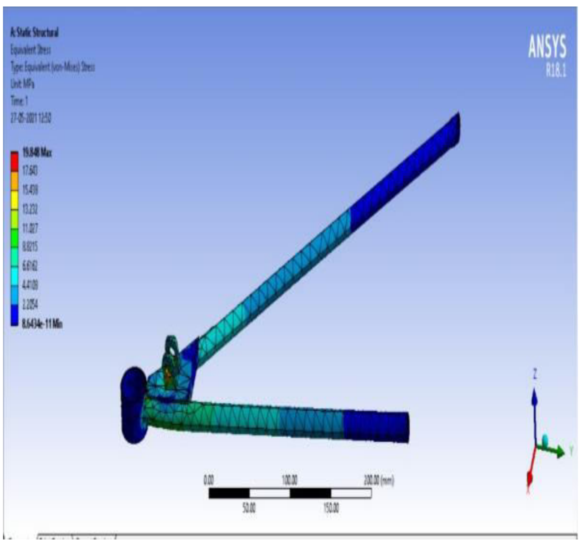
REAR UPPER A-ARM

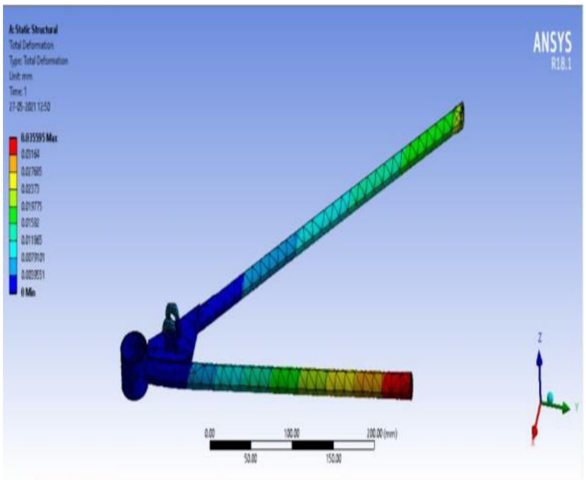




Equivalent stress and total deformation rear upper A-ARM

REAR LOWERA- ARM





Equivalent stress and total deformation rear lower A-AR

RESULT

	Equivalent stress	Total deformation	Equivalent elastic strain	Safety factor
Front upper A-ARM	17.052	0.015051	8.5929e-5	5.0552
Front lower A-ARM	15.725	0.042862	8.1575e-5	5.4818
Rear upper A-ARM	17.932	0.13145	8.9849e-5	4.807
Rear lower A-ARM	19.848	0.035595	0.00010268	4.3429

Table -3 RESULT

CONCLUSIONS

As the main objectives of this thesis were to gain a better understanding of how to pull and push rod suspension systems to work and combine theory and practical knowledge by designing and modelling the pull pushrod suspension system. In the thesis suspension properties like camber, caster and kingpin inclination angle was explained and what effects on the overall handling of the car they have. How the design could be as simple as possible without sacrificing performance is explained. Lowering the COG by using pull rod suspension instead of pushrod suspension. Designing an active suspension system and the possibility of having no anti. After the design of each component of the suspension system, an assembly was created to verify the design and that no interference was between components.

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