DESIGN AND OPTIMIZATION OF FORMULA CAR SUSPENSION SYSTEM

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Abstract:

Automobile industries are one of the emerging industries. Suspension System plays a crucial role in automobiles. A good suspension system provides Required ride comfort, perfect cornering and perfect control over the vehicle. In this paper Design and optimization of A-arms, Bellcranks, Hub Uprights, pushrods, A-arm Clamps, Damper mount clamps were done considering all the possible dynamic Performance and load parameters.[1]

INTRODUCTION:

The suspension system is a mechanism which is used to provide driver comfort and vehicle stability. especially in formula cars, speed and performance are one of the major considerations with proper stability and control of the vehicle. In this paper design and optimization of formula car suspension system is been made considering the vehicle's stability, safety, and driver's comfort according to formula track conditions. Many iterations and analysis were made using ANSYS and LOTUS SHARK for different vehicle conditions, Forces due to dynamic loads, etc.[1,2]

Design Criteria and Considerations

- Proper camber control
- Proper castor.
- Proper toe.
- Low un-sprung mass
- Effective handling during acceleration, braking, and cornering
- Minimum wheel travel
- Optimization between comfort and performance
- Minimize chassis roll, limiting roll camber gain and roll steer and provide more grip during cornering

Why Pushrod Suspension?

- Improved wheel rate control
- Ride height adjustments with suitable rocker arms
- Greater flexibility in positioning the shocks
- Reduction of vehicle's coefficient of drag
- To provide traction to the wheels

Considerations for selection of Springs & Damper:

1. Availability
2. Cost
3. Minimum Wheel travel
4. Motion ratio
5. Required ride frequency
6. Adjustable static ride height.
7. Adjustable rebound speed.

Design methodology

- The wheelbase and track widths are decided based packing, compactness and design rules.
- Pushrod suspension have yielded better control of camber and toe-in bump, roll and steer conditions
- A-Arms are designed to provide static negative camber.

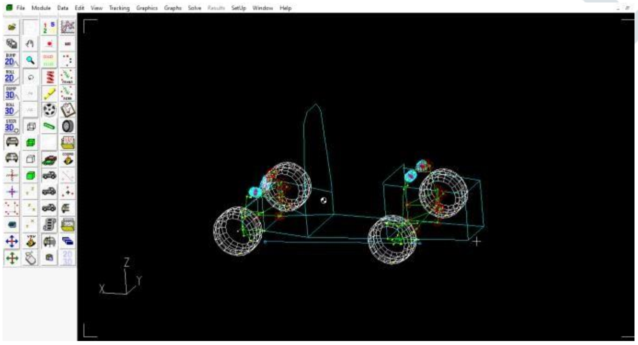
- Pickup points are places at nodes for easy cornering force distribution.
- Vertical clamps to allow free moment.
- Ride height is adjusted using shocks with adjustable stiffness
- Damper rates are adjusted based on the vehicle performance

Overall Suspension Parameters

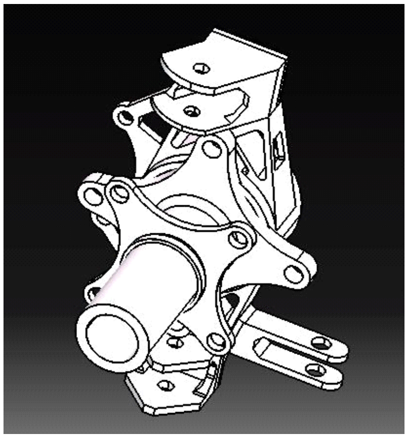
Parameter	Front	Rear
Type of Suspension	Inboard, Pushrod	Inboard, Pushrod
Spring stiffness	40N/mm	40N/mm
Wheel frequency	4.2hz	3.6hz
Induced Camber	-1.5 deg	0 deg
Kingpin Inclination	5 deg	0 deg
Caster	5 deg	0 deg
Scrub Radius	120mm	130mm
Motion ratio	0.41	0.42

After performing various iterations for A-Arms & suspension geometry using LOTUS SHARK Suspension Simulation software.

The following graphs show the results:



Lotus Suspension Design



Hub and upright (CAD MODEL)

TIRES:

Type: 10” Hoosier wet tires

Construction: Cross ply

Wheels specifications:

- Diameter = 10”
- Width = 6”
- Offset = 1” negative
- Thickness = 0.125”
- Pitch Circle Dia = 110mm
- Material = Heat treated Aircraft grade Aluminium 6061

Selection Criteria:

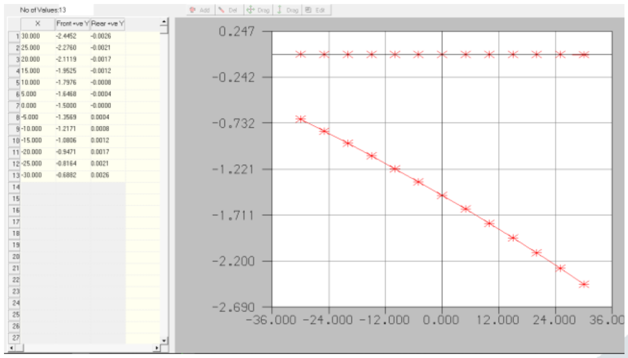
- Lighter in weight
- Ease of availability
- High durability

Reasons for selection:

- Low unsprung mass
- Provides high traction
- Easier handling
- Helps to reduce CG height
- To maintain lower ride height

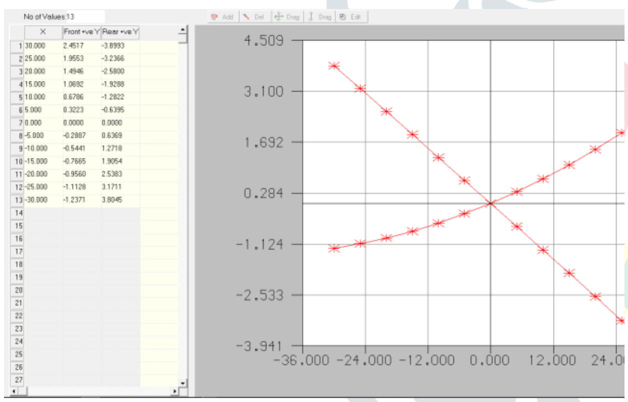
GRAPHICAL OPTIMIZATION AND RESULTS

Parameter Vs Bump



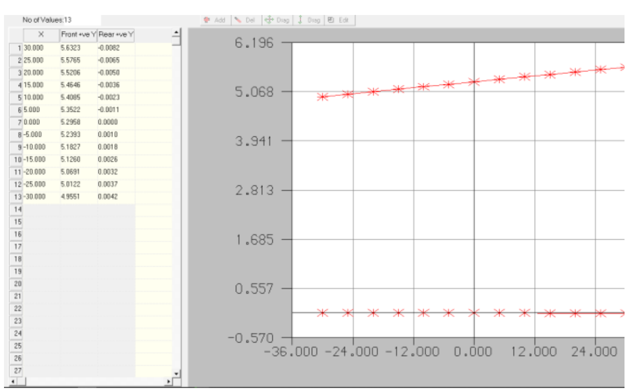
(Camber Vs Bump)

- Adjusting front camber and rear camber in such a way that they do not fluctuate over their limit during a bump.



(Toe Vs Bump)

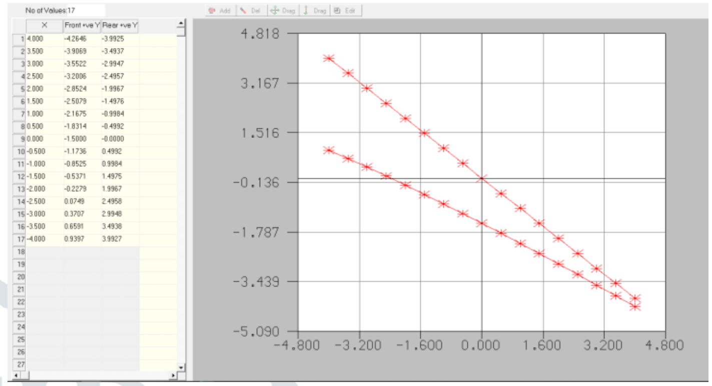
- Toe is fixed in such a way that they support straight-line action during high speeds.



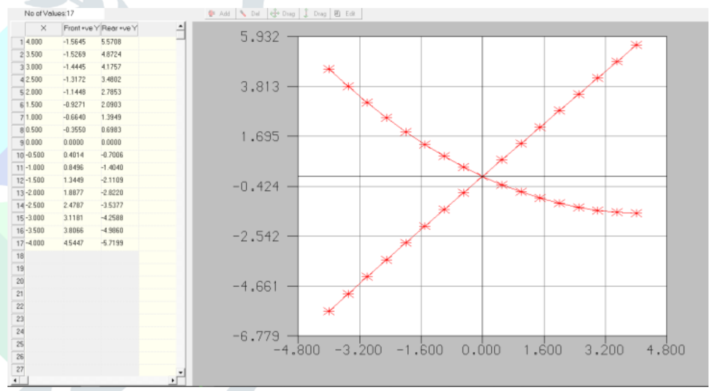
(Castor Vs Bump)

- A-arms are made with proper positive camber so that the vehicle aligns on high speeds.

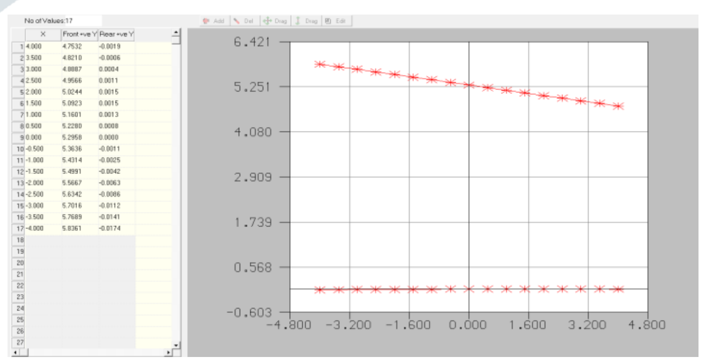
Parameters Vs Roll



(Camber Vs Roll)

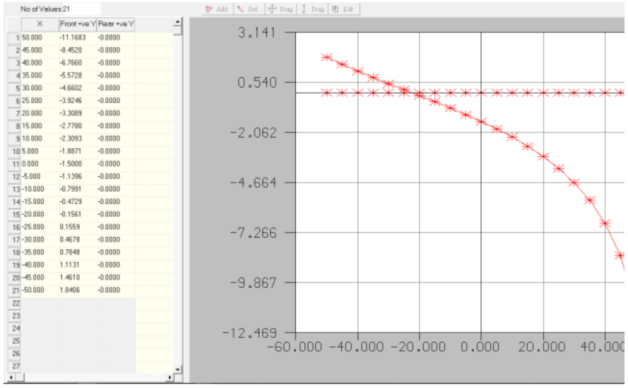


(Toe Vs Roll)



(Castor Vs Roll)

Parameter Vs Steer



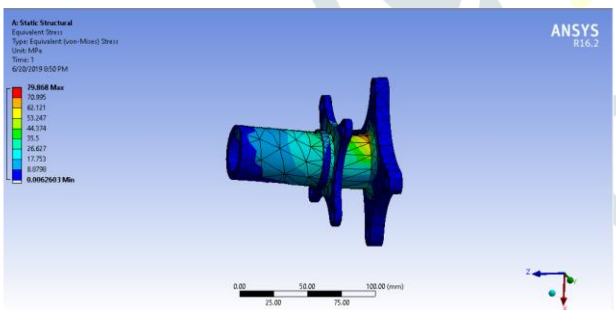
(Camber Vs Steer)

HUBS AND UPRIGHTS:

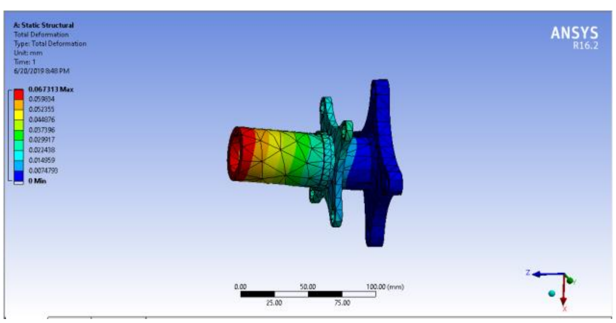
In order to have low unsprung mass, we have chosen Aluminium 7075 T6 material and have designed custom Hubs & Uprights.

These were designed by considering all the suspension parameters, dimensions suitable for wheel assembly and also to withstand all the bump forces acting on it.

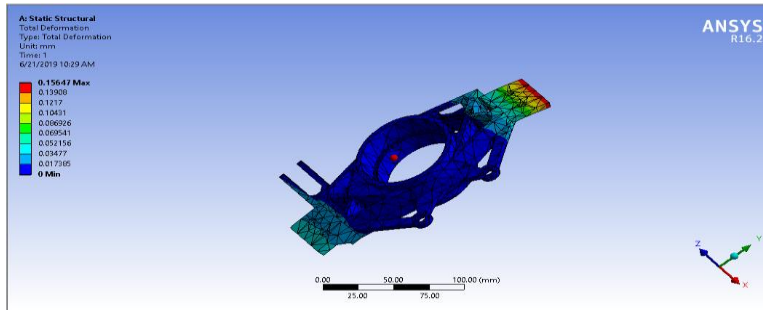
Structural analysis is done considering different forces acting on them like **bump force** and **lateral loads.**



Equivalent stress

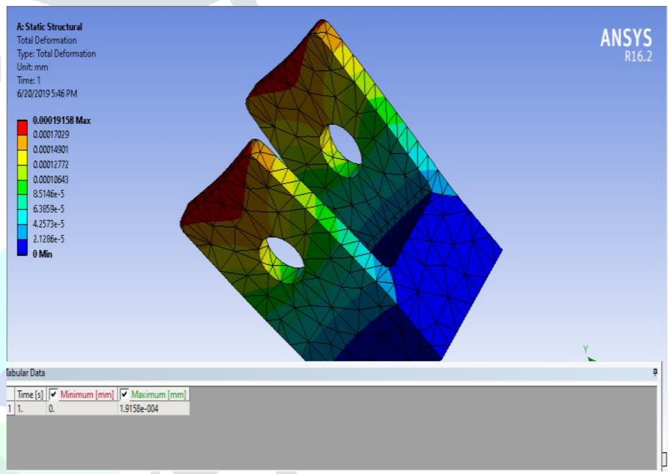


Deformation

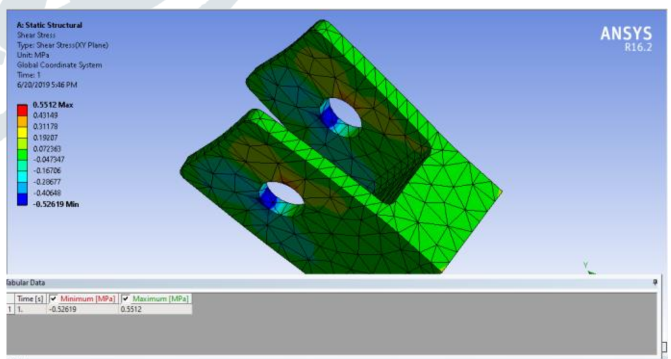


Upright Deformation

A-arm CLAMPS



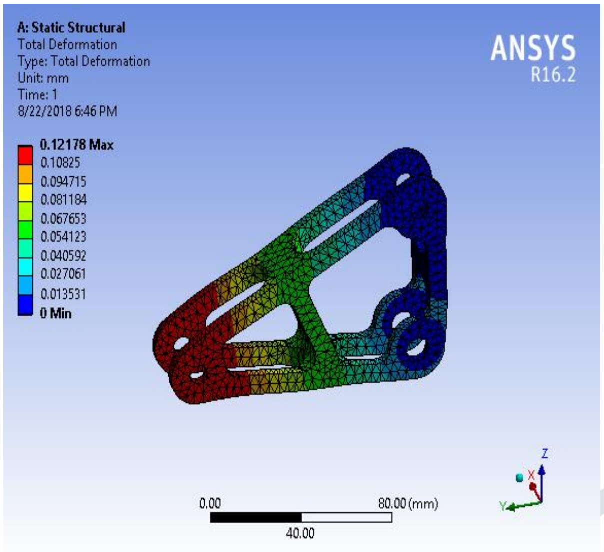
Deformation of clamp



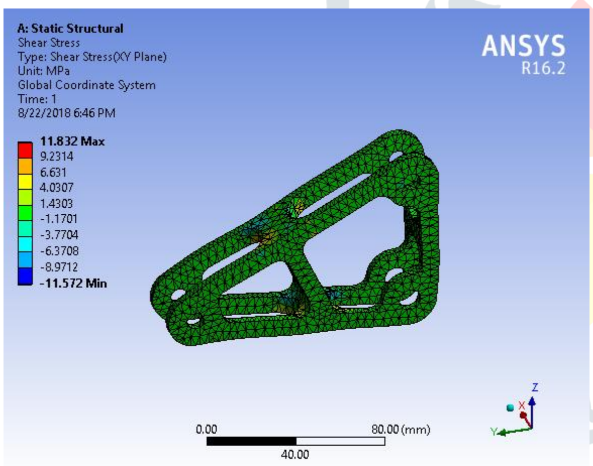
Shear stress on clamp

Mounting clamp for A-arms has been designed and analyzed considering **braking force** and **lateral force.**

Bellcrank



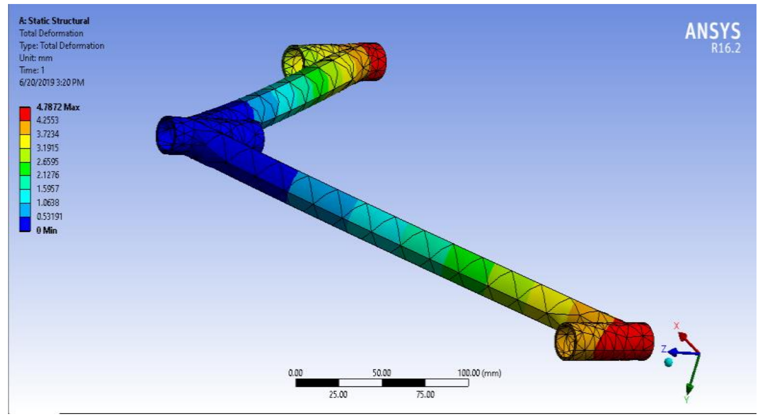
Deformation of bell clamp



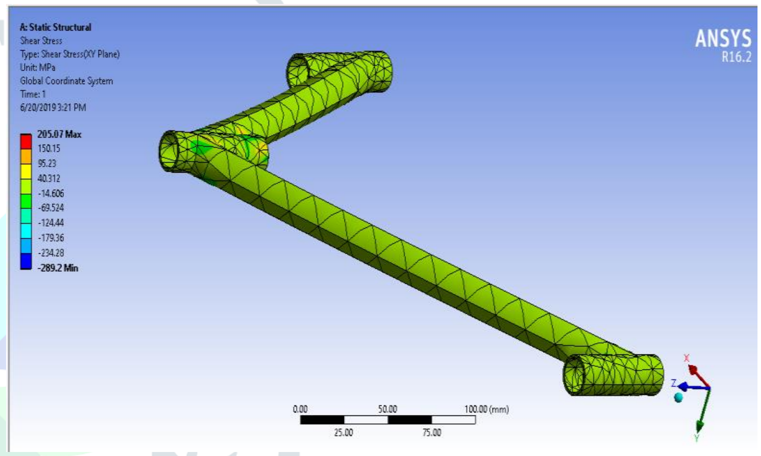
Shear stress

Design and analysis of bellcranks considering **Bump force.**

A-arms



Deformation of A-arms

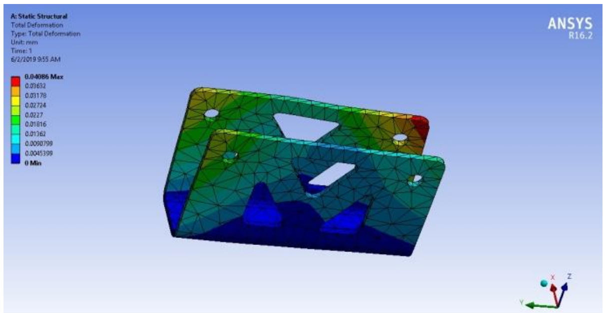


Shear stress of A-arm

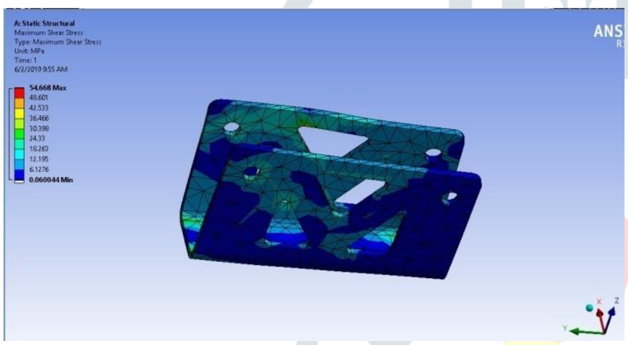
considerations for Design and Analysis A-arms:

- Castor
- Camber
- Instantaneous center (IC)
- Roll center
- Distance between the Center of Gravity and IC
- Longitudinal force
- Lateral force
- braking forces.

Suspension mounting clamps

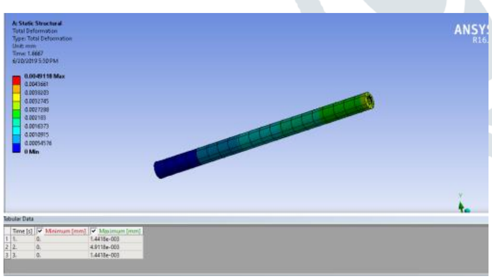


Deformation on suspension mounting clamp



Shear stress on suspensions mounting clamp

Pushrod



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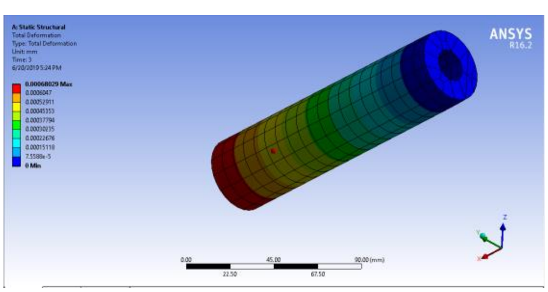
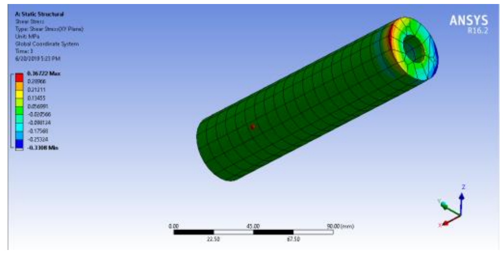
Deformation on the front pushrod



Deformation on Rear pushrod



Shear stress on Rear pushrod

- ➢ Fatigue analysis considering Bump force.

REFERENCES

1. 'Optimization of Vehicle Suspension System to Improve Comfort' by E. S. Fernandes, S. S. Sheth, K. K. Nawpute, V. V. Kadam, A. C. Mitra (Department of Mechanical Engineering, M.E.S College of Engineering, S.P. Pune University, India)| IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE)|e-ISSN: 2278-1684,p-ISSN: 2320-334X.
2. A. C. Mitra, G. R. Kiranchand, S. B. Dhakare, M. S. Jawarkar, Optimization of Passive Suspension System for Enhancement of Ride Comfort, IOSR Journal of Mechanical & Civil Engineering (IOSRJMCE),2016,1-8.