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DESIGN AND FABRICTION OF SUSPENSION SYSTEM FOR FORMULA STUDENT VEHICLE

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Abstract - The main criterion of this project is to design the suspension system for the formula student vehicle, this is typically achieved by Push-rod, Up-right, Rocker arms, Antiroll bar. To provide the smooth suspension of the vehicle, this system creates. There was design of compons and calculations of them for required smooth operation of suspension system, the complete knowledge about the working and mechanism and modelling of the suspension system is covered. We deal about the design process consists of first determining the suspension system given data and geometry and analysing it on lotus suspension software after analysis and optimization of the geometry the entire system is designed in solid works .Different analysis were performed while iterating and getting the best possible design which is suitable for our vehicle and also for the rider .The overall components design and modelling of suspension system for our vehicle was done and tested and proved to be reliable in all possible working condition

***Key Words*:** suspension, tires, push-rod, pull-rod, rocker arm, up-right.

1. INTRODUCTION:-

The suspension system includes the of tires, damper, spring, A-arm, linkage which are connected to the vehicle and the wheels and allowed relative motion in between the Suspension systems which supported the roads holding/handling and to the ride quality. Hence this provides a mechanism to isolate the body from the bumps roads. The springs manipulation the continual of un even road and check out to bring them into a more manage the band. They also provide the damping action through friction and own hysteresis from dampers spite the energy for the dynamic load coming through the bump's roads. To safeguard the reside from road shocks and to obtain the stability of the vehicle in pitching or rolling, while in motions Working of the suspension system control arms or links allow wheel are movement independent of the vehicle.

2. METHODOLOGY:-

Yaw movement

A yaw movement could also be a movement around the yaw axis of a rigid body changes the direction it's pointing, to the left or right direction of motion. It is usely commonly measured in degrees/second or radian/second. Another important concept is that the yaw moment which is the components of a torque about its yaw axis.

Anti-roll bar

An anti-roll bar which is used is a part of many suspensions system that helps reduce the body roll of a vehicle during fast turning or over bump road. Anti-roll bars were unusual on cars thanks to the wide much rigid suspension and acceptance of body roll. A roll bar increases the suspension system roll stiffness' its resistance to appear turns, independent of its spring rate within the vertical directions.

Track width

On most vehicles, the track width will differ between the front and rear axis since they are to perform different functions. A vehicle's track, or track width, is that the distance differs between the center line of every of the wheel on an equivalent axle on any given to vehicle.

Wheelbase

In road and rail vehicles, the wheelbase is that the space between the centers of the front and rear axial wheels. For road vehicles with quite two axles the wheelbase is that the distance between the steering axle and therefore the center point of the live axle group.

3. LITERATURE REVIEW:-

Soliman 2011: Presented method LQR control design is for the control of a vehicle suspension full vehicle model was used studying the effect of the control system active suspension system on riding performance. The dynamic and acceleration tire load were estimate. For the time static analysis, different bumped conditions are considered so as to show the performance of the controllers. The simulation results show that system gives a far better ride performance compared with system.

Yoshimura eta.: Built an active EMS using the concept of relative motion control. According to that, the motion control was much better than LQ control concept and passive suspension. Analytical solution was wont to design the suspension. As a result, the suspension system using sliding mode control was much better than active suspension that using LQ control concept and passive suspension system in terms of vibration.

Lin etal.: Proposed a reitr motion mode controller to control the suspension system and evaluate its control performance. The employed the error of the spring mass position and therefore the error change to determine a sliding surface, then introduced the sliding surface and therefore the change of the sliding surface as input data of a standard fuzzy controller (TFC) in controlling the suspension. However, no substantial improvement within the ride comfort might be obtained with the FSMC relative to the TFC because the dynamic effect of the spring mass acceleration from the bouncing tire during tire rotation was not eliminated.

V.D.Thorat, Prof P.Deshmukh: Developed rigid multi body dynamic analysis approach in design. the correct result. In this first consistent with Ackerman conditions are basic geometry is meant for static load, model analysis then for dynamic foresees generated on steering linkages while turning using Rigid Dynamics tool in Annoys. Results are shown rigid dynamics mode for design reduces time for development, simulation and supply to the prospect to require most reward action. Author concluded that rigid dynamics approach is employed in modern design techniques for various domains.

4. CALCULATIONS:-

Ride and Roll Rates: For determining the spring rates the ride and roll rates are essential.

$$\theta\ /Ay= -W\ x\ H/\ \ K\varphi F+\ K\varphi F$$

Where,

θ=roll angle in degrees

Ay=lateral acceleration in G's

W=total weight of vehicle in Newton's

H=center of gravity height in m's

KφF=roll rate at front in Newton-meter/degree

KφF=roll rate at rear in Newton-meter/degree

Front spring: Material=music wire (ASTM-A228)

Wire diameter=6mm

Outer diameter=44mm

Free length=140mm

No. of coils=9

Total no of coils=11

Rear springs: Material=spring steel

Wire diameter=5mm

Outer diameter=44mm

Free length=140mm

No. of active coils=6mm

Total no. of coils=8mm

Damper Selection:

For the obtained spring rates no. of dampers are available. To test the damper as we are new team the dampers, we had chosen are DNM 22 LAR. The dampers have possessed with adjustable jounce and rebound.

Front and roll anti-roll bar stiffness:

$k\emptyset fa = k\emptyset a^{*}Nmag * mr2/100$

K φ FA = FARB roll rate (Nm/deg twist)

KφA = Total roll rate (Nm/deg roll)

Nmag = Magic Number (%)

MRFA = FARB Motion ratio.

And the total roll stiffness is 345 N-M/degree. By using torsion equation

$$T / J = C * \theta / L$$

We obtained,

The ARB lever length =100mm

5. DESIGN PARAMETER:-

DESIGN FACTORS

Tire Dimensions:

Tire dimensions are the ratio of the height of the tire's cross-section to its width. The dimensions of the tire are about 175/13/60 tire dimension consists of the outer diameter of the tire, width of the vehicle and the radius of the rim. The wheel has an outer diameter of 13inch.

Camber:

Camber is the tilting of the wheel (measured from the top), so tilt out at the top is defined as "positive-camber" and tilt in at the top is defined as "negative-camber" The camber adjustment to the vehicle is about -1.5.

Mass of the vehicle:

The total mass of the vehicle is about 330kgs

Out of total mass front, mass is 148.50kgs

Rear mass is 181.50 kg

Steer arm:

A steering arm is the final part of steering set up and pushes/pulls the hub in order to gain directional control over the front wheels.

The length of the steering arm is about 118.36mm.

TOE POINTS:

In automotive engineering, toe, also known as tracking, is the symmetric angle that each wheel. Negative toe, or toe out, is the front of the wheel pointing away from the centerline of the vehicle. Positive toe, or toe in, is the front of the wheel.

Camber	-1.5 front, 0 rear
Toe	0,0
Kingpin indication	6,0(in degrees)
Caster	7,0(in degrees)
Roll angle	2 degrees
CG	300
Sprung mass	180
Unsprung	50
Tire dimension	175/R13/60(same at front and rear)
Track width	1.204m,1.193m
Wheel base	1549.4mm
Wheel travel	35bump,35 droop
Scrub radius	40mm,45mm (at front and rear)

Parameters to be considered for the vehicle:

The overall dimensions of the vehicle are the

length of the vehicle is 2804.16 mm

Width of the vehicle is 1463.04 mm

Height of the vehicle is 1220 mm

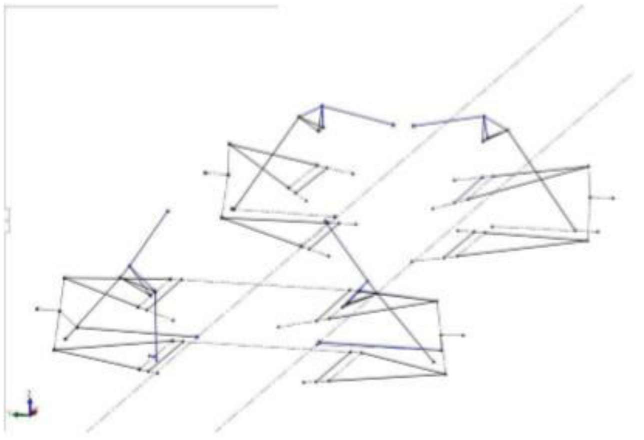


Fig:-1 hard point of chassis

Arms Design:
The a-arms are manufactured using mild steel hollow rods. Of 16 mm outer diameter and 10mm inner diameter. They are mounted to frame directly through rod ends i.e. ball bearings, and the ball bearing is placed in between the triangular bushes so that the bush is in double shear. And the outer side i.e. the upright is of the wishbones is welded to the casing which is equipped with a spherical bearing in And the spherical bearing is mounted in the knuckle. The wishbones converging is welded to the mild steel casing of outer dia 34 mm and inner dia 22 mm. circles are inserted in the casings to ensure the fixed position of spherical bearings. To the lower wishbones a wafer is welded to hold the push rod mount. Triangular bushings are inserted at all mountings like wishbone mounts to frame, spherical bearings, pushrod mountings, and rocker mountings so that to avoid single shear.

Rockers:
Rocker arm is a kinematic link which varies the motion according to the motion ratio provide for the suspension. Design of rocker arm, the inputs is drawn from the software. Modeling of the rocker is designed in solid works by using the specific tools for modeling considering the material for the rocker is stainless steel. And fabricated by using the TIG welding process according to the design.

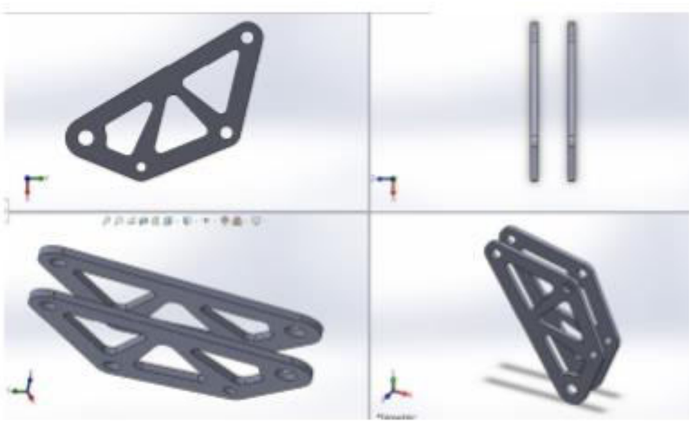


Fig:-2 front rocker

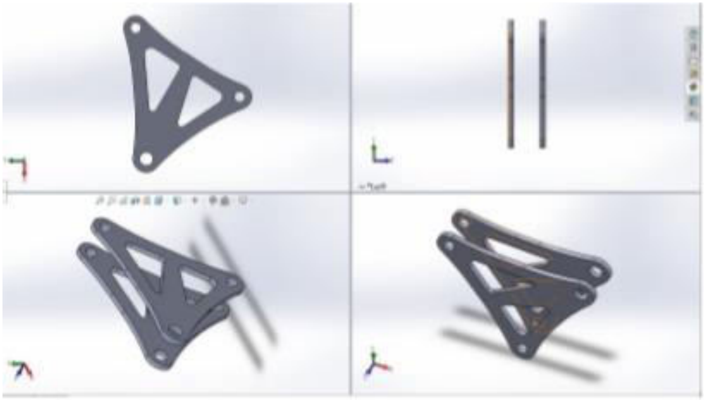


Fig:3 Rear rocker

Rear Damper Mounts:
It is support the damper and spring of the suspension system with the help of the a-arm and Rocker.

Fig:4 Rear rocker mount

6.ANALYSIS

A-Arm Analysis:
The a-arm calculations are made according to the condition of cornering and breaking at a single instance so the total weight transfer takes place to the front left wheel i.e. during right turn. According to the analysis the a-arms can with stand a maximum load of 2500.

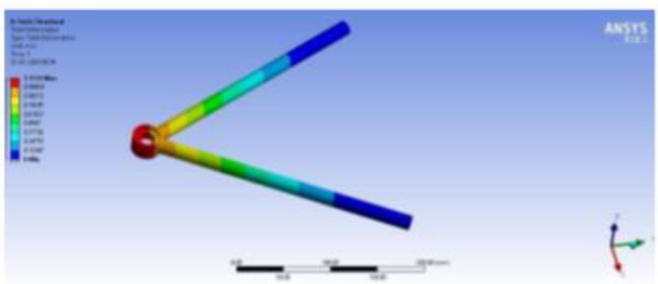


Fig:5: analysis of front lower wishbones

At a force of 2000N the maximum deformation suffered by the wish bone is 1.11mm.

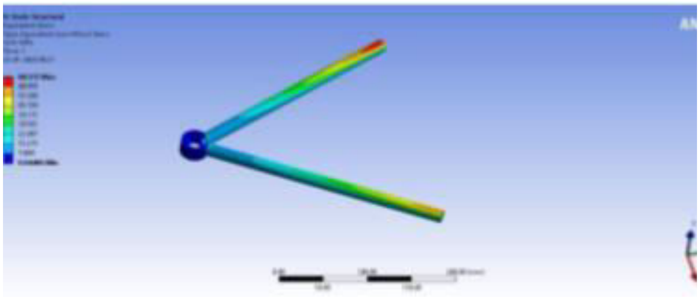


Fig:6.front upper wishbones

The total equivalent stress acting is 68.752MPA at the rod ends.

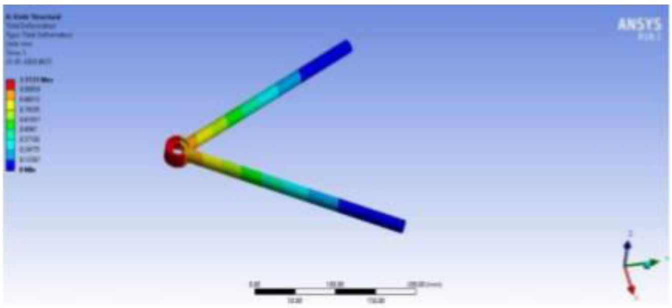


Fig:7.Rear lower A-arm

The maximum deformation suffered by the wishbone is 1.1131mm at a load 0f 2500N.

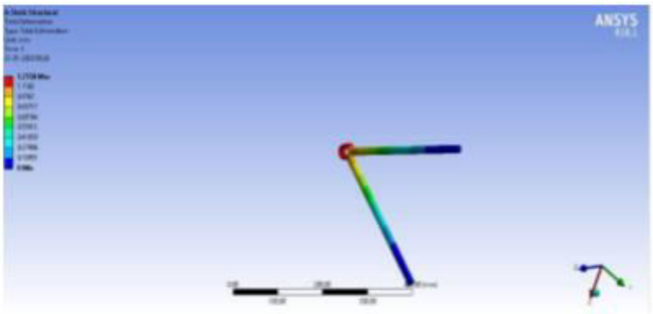


Fig: 8.Rear upper A-arm

The maximum deformation suffered by the wishbones is 1.2558mm, at a load of 2200N.

Front Rockers:
Material description: Mild Steel of 4mm thick
Yield strength-250Mpa
Ultimate tensile Strength-840Mpa
Design consideration:
1. Damper dimensions
2. Rocker ratio
3. Node and push rod upper point from suspension geometry
Meshing;
Method-Tetrahedrons
Size-1mm

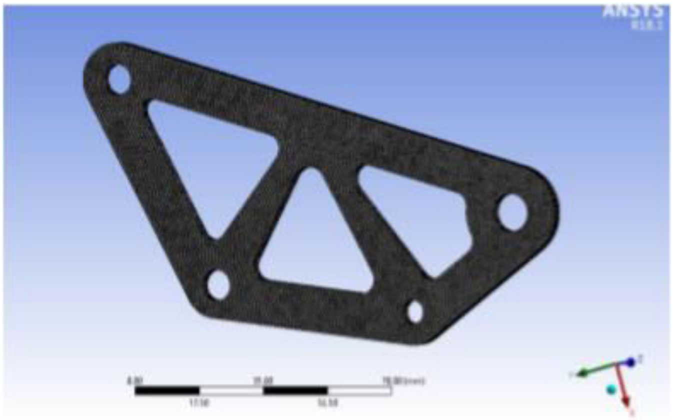


Fig: 9.Meshing of front rocker

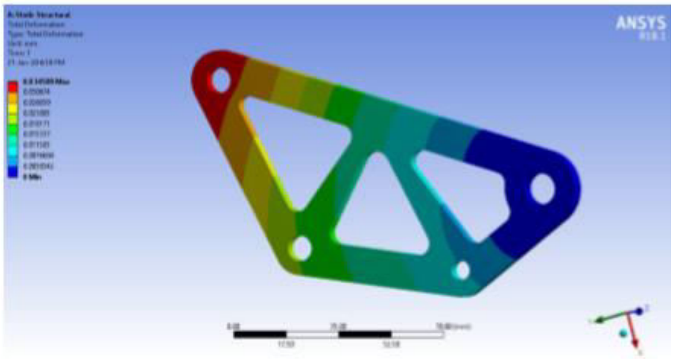


Fig: 10.Total deformation of front rocker

Front Damper Mounts :
Material description:
Mild Steel of 4mm thick
Yield strength-250Mpa
Ultimate tensile Strength-840Mpa
Design consideration:
1. Damper position and dimensions
Meshing:
Method-Tetrahedrons,
Size-1mm

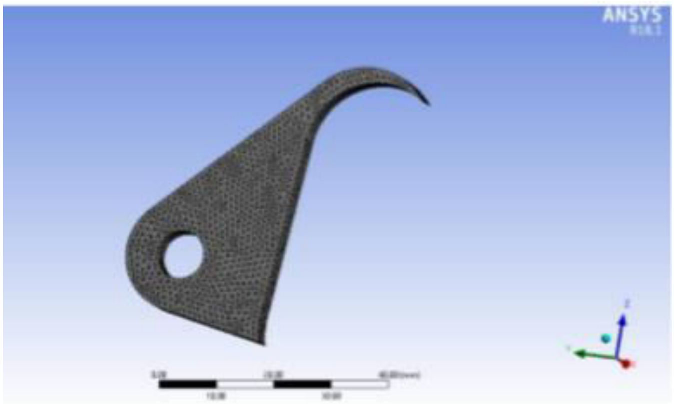


Fig: 11. Meshing of front rocker mount

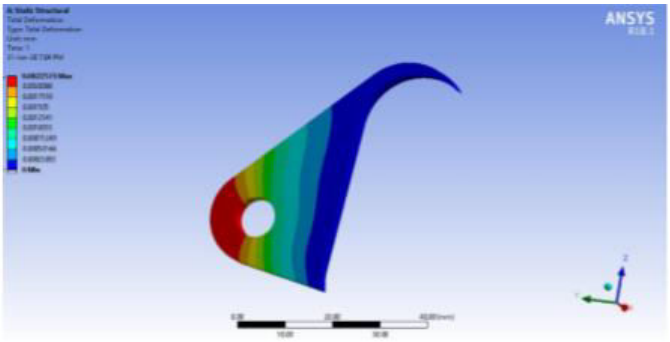


Fig: 12. Total deformation of front rocker mounts.

Rear Rockers:
Material description: Mild Steel of 4mm thick
Yield strength-250Mpa
Ultimate tensile Strength-840Mpa
Design consideration:
1. Damper dimensions.
2. Rocker ratio.
3. Node and push rod upper point from suspension geometry.

Method-
Tetrahedrons
Size-1mm

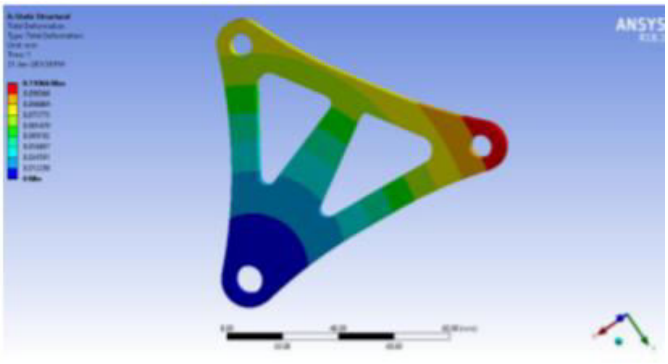
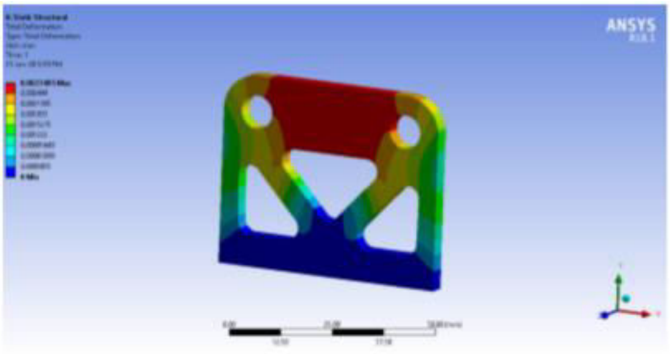


Fig:13. Total deformation of rear rocker

Rear Damper Mounts
Material description:
Mild Steel of the 4mm thick
Yield filed strength-250Mpa
Ultimate Strength-840Mpa



7. PROTOTYPE IMAGES

Fig: 14.Total assembly of suspension system

8. CONCLUSION

We have gone through various parameters and analyzed many design iterations. At last we have designed and fabricated the suspension system for formula Bharath vehicle. We have added many different components to this suspension system such as push-rod, upright, rocker to then the ww arms, anti-roll bar. This system provides enough comfort to the driver and to the whole vehicle. As we mentioned earlier, we used LOTUS Shark software to determine the suspension parameters and its geometry. The software gave pretty accurate results which can be compared to the real-life analyzed on vehicle. Suspension system is designed according to the rule book of formula Bharath in which we are going to participate. Various parameters, starting from tire dimensions to caster, camber, KPI, to in, C.G, roll angle, each and every essential parameter is considered. Suspension system works while collaborating with other departments in a vehicle such as chassis, steering, power engine train and braking. The design has considered all those parameters to reach the optimum goal of obtaining a best suited suspension system to the vehicle. Overall suspension system is tested at the most possible working conditions. Analyzed results proved that each and every component from the I n gteh suspension system is reliable in all those possible working conditions.

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