DESIGN AND ANALYSIS OF SUSPENSION SYSTEM, BRAKES AND WHEEL ASSEMBLY FOR AN ALL TERRAIN VEHICLE – A DESIGN REPORT

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Abstract - *This design report explaining Engineering design process and analysis of All Terrain Vehicle (ATV) which has been developed for the Rally Car Design Challenge 2019. The main idea of our project is to get practical knowledge in the field of both mechanical and automobile trying to grasp finest concepts in the design, manufacturing and marketing sectors. Our project is to build an ATV that is capable to run on roughest and one of the most uneven roads present. The prerequisite of our design is that it should be rigid enough to withstand the shocks created by the impact when the car jumps from a height of 5 meters. Senior design project enables student to gain real world experience in the design, Analysis and Manufacture the vehicular product. Solidworks 2016 has been conducted on all important parameters of ATV to ensure the safety. This report is details of procedure and methodology used for the Design Of ATV.. The main criteria considered in the design included High performance, reliability, Manufacturability, serviceability, weight and cost.*

Key Words: Engineering management, Performance, All Terrain Vehicle, Safety, Brakes.

1.0 INTRODUCTION

The design process of this single-person vehicle is iterative and based on several engineering and reverse engineering processes. Following are the major points which were considered for designing the off road vehicle:

- Endurance
- Safety and Ergonomics
- Market availability
- Cost of the components
- Standardization and Serviceability
- Manoeuvrability
- Safe engineering practices.

Team Triumphant Racers began the task of designing by conducting extensive research for main parts of the vehicle. We contacted numerous auto part dealers in different parts of the country to know the availability of required parts. Then keeping the voluminous list of available parts in mind, the designing team initiated their work to achieve the best standardised as well as optimised design possible. Solidworks 2016 software was used for designing and analyse the Impact test and all. We used Lotus Software for suspension simulations and Transmission simulations. Specifications laid down by the rulebook were the foremost concern while designing and selection of the parts. Besides performance, consumer needs of serviceability and affordability were also kept in concern which we got to know through the internet research and reviews for all terrain vehicles.

2.0 SUSPENSION SYSTEM:

An ATV is supposed to have the best of the suspension systems than the other categories of vehicles. The unpredictable nature of off-road racing creates the need for a reliable and efficient suspension system. Selection of suspensions was based on the criteria of their degree of freedom, roll-center adjustability, ease in wheel alignment parameters etc.

The design **objectives** of the suspension system were:
1. Improve vehicle handling
2. Increase the ride height and total wheel travel
3. Improve durability of components

Suspension Geometry is as follow:

Parameters	Front	Rear
Suspension type	Double wishbone	H-arm
Wishbone material	A106	A106
CG Height	25”	13”
Roll Centre Height	12.4”	12.8”
Suspension Travel	5.5”	5.5”
Track Width	55”	51”
Total Weight	660kg (Front=360/Rear=300)	
Wheelbase	75”	
Effective Wg of ATV	840kg (Front=331kg/Rear=510kg)	

Roll Gradient	-0.715°
Lateral Load	Front = -213.31kg Rear= -241kg
Ride Rates	Front=42.64 kg/inch Rear =52.01 kg/inch
Motion Ratio	0.5
Camber(deg)	0
Castor (deg)	5°
Ride Frequency	Front = 1.79 H_z Rear = 1.59 H_z
King pin Inclination	9°
Sprung mass	540kg
Unsprung mass	115kg
Spring Stiffness	F/R = 20/25 N/mm
Roll Rate	Front = 2683.39 lb.ft/rad Rear = 2924.238 lb.ft/rad

Based on above parameters, Suspension system was designed and analyzed with the help of Lotus Software and Solidworks 2016.

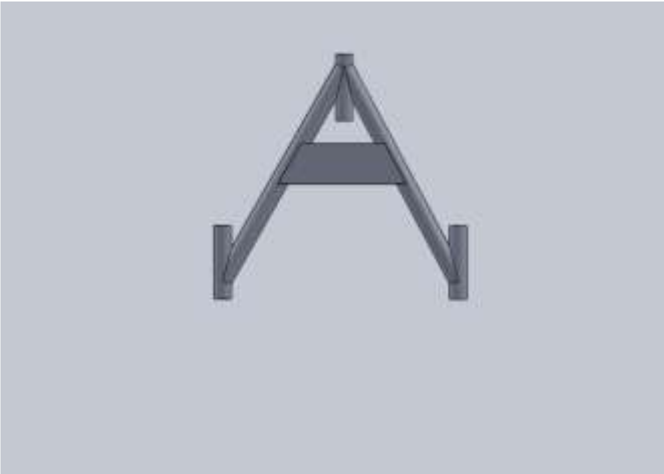


Fig - 1 : Front Lower arm

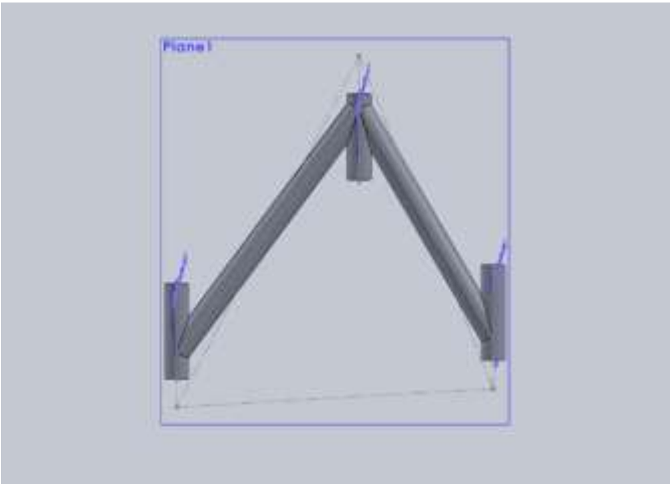


Fig - 2 : Front upper arm

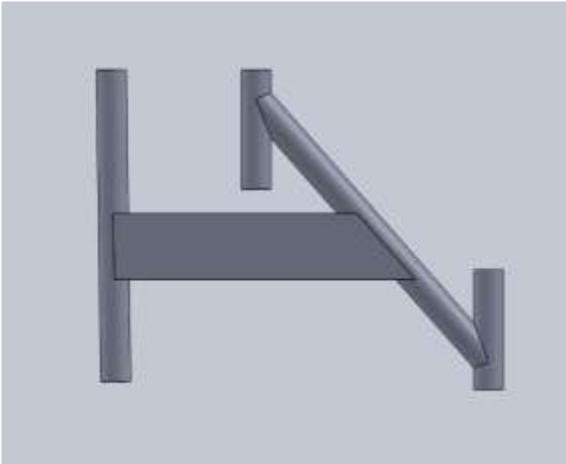


Fig - 3 : Rear Lower H-arm

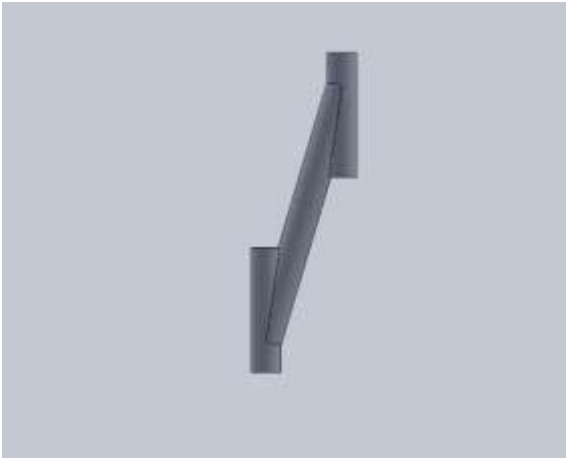


Fig - 4 : Rear upper arm

2.1 FRONT SUSPENSION DESIGN

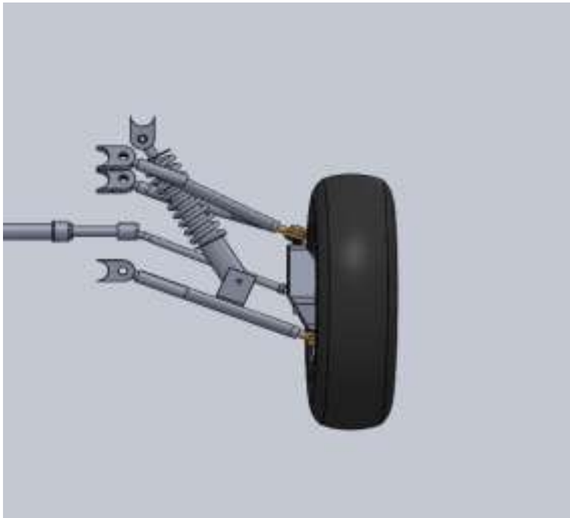


Fig - 5 : Front a-arms with suspension

Fig - 6 : Front a-arms with suspension

2.2 REAR SUSPENSION DESIGN

Fig - 7 : Rear H-arms with suspension

Fig - 8 : Rear h-arms with suspension

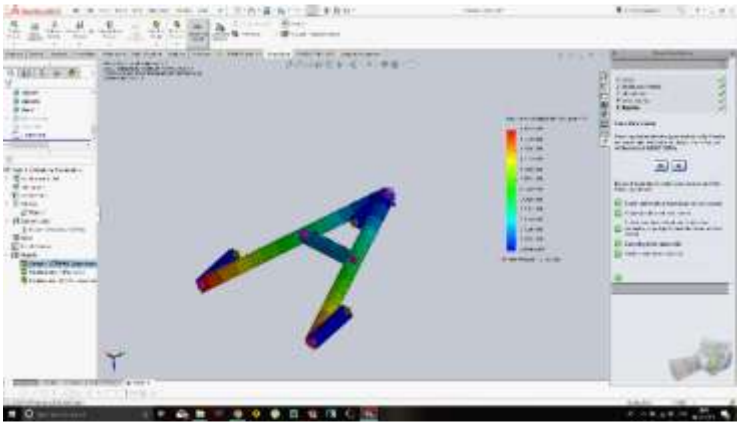


Fig - 9 : Front Lower arm and Rear H-arms

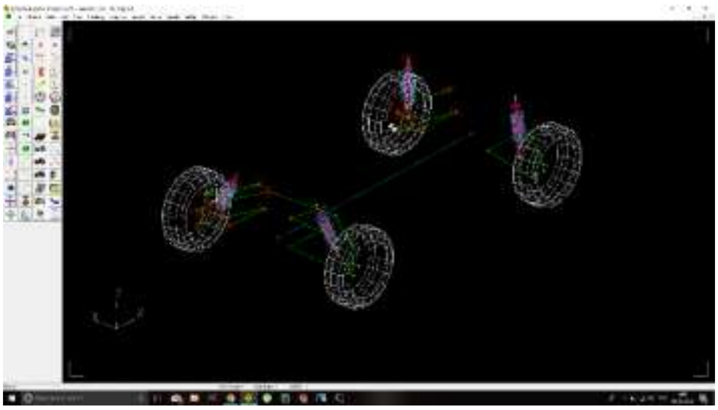


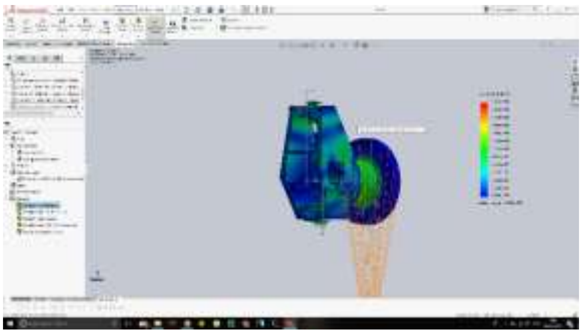
Fig - 10 : Suspension Analysis in Lotus

3.0 Wheel Assembly:

There are a lot of forces acting on the wheels in the static and especially in dynamic condition. As the wheel assembly is directly connected to the wheels, all the forces have direct impact on designing of wheel assembly.

Objective :

- Reduce unsprung mass.
- Light weight to maintain good performance to weight ratio of the race car.



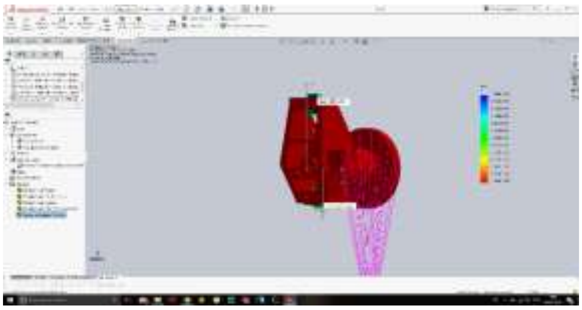


Fig - 11 : Front Knuckle analysis

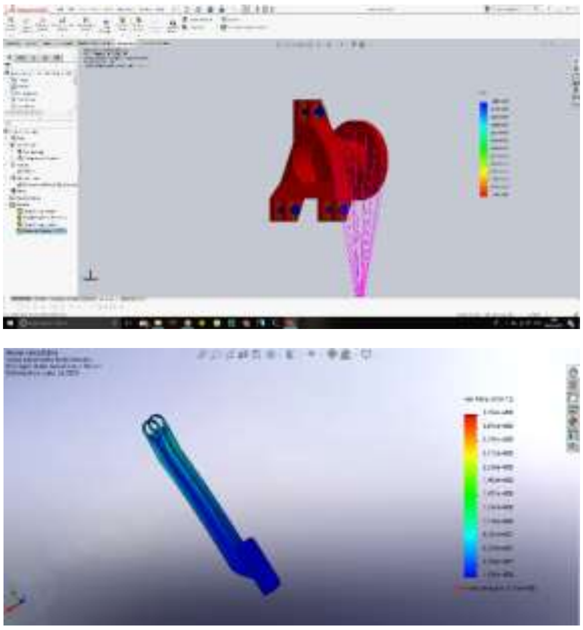


Fig - 12 : Stress Analysis on Rear Knuckle

4.0 BRAKING SYSTEM:

An excellent braking system is the most important safety feature of any land vehicle. Competition regulations require at least two separate hydraulic braking systems, so that in the event of a failure of one, the other will continue to provide adequate braking power to the wheels. The main requirement of the vehicle's braking system is that it must be capable of locking all four wheels on a dry surface. Ease of manufacturability, performance and simplicity are a few important criteria considered for the selection of the braking system.

OBJECTIVES

The goals for the braking system were:

- To stop the Vehicle within desired limit.
- Reduce weight in the overall system.
- Increased reliability

Braking Calculations :

Static Axle Load Distribution (Ψ)

Ψ = Static Rear Axle mass/ total mass

Ψ= 360/660 = 0.54

Braking Force (B_F)

B_F = Total Vehicle mass * deceleration * g

= 660 * 30.27 * 9.81 = 20044.2 N

Brake Torque (T_b)

T_b

= B_F * radius of tyre /speed ratio between wheel and brake = 6013.26 Nm

Brake Clamp Load(C)

= Brake Torque

/ effective radius(r_e) * coefficient of friction * no of friction faces(n=2)

C = 1978.04 N (r_e= 1.52 m)

Hydraulic Pressure Generated by master cylinder (P_{mc})

= Brake pedal force (F_{bp})

/ Area of master cylinder

= 1600 / 0.285 = 0.005614 MPa

Brake Pedal force

= force applied to pedal by driver

* pedal ratio

= 400 * (24/6) = 1600 N

Stopping Distance (S)

S = v^2 / 2g * a_{avg}

(v = velocity

a_{avg} = average deceleration

a = deceleration)

a_{avg} = v / (v/a) + 0.3 g)

= 4.76 m /s^2

S = 3.05 m

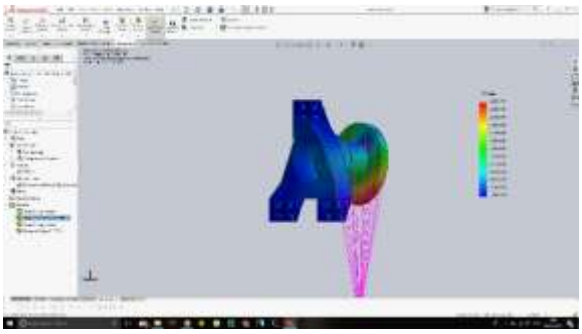


Fig - 13 : Stress analysis on Brake pedal

Based on above calculations as well as considering weight, FOS and performance, Maruti C51 Calipers were chosen at front and rear tires respectively.

Considering the calculations done for finding piston diameter of master cylinder, TVS Girling 2586 master cylinder is used

Parameters	Value
Brake Master Cylinder	Bore Dia = 0.6023m
Brake Caliper	Bore Dia = 60 mm No of Piston = 1
Brake Fluid	DOT 3
Stopping distance	3.05 m
Max pedal Force	400N
Weight Transfer	F/R = 2550/3924
Staic Rolling Radius	11"
Friction Coefficient of road	0.7
Force Required by Caliper	20044.2 N
Simultaneous Locking	Yes

5.0 Conclusion:

When undertaking any design project there are several factors to be considered that are common to all engineering projects. A project must have a proper scope with clearly defined goal. Our team is participating for the first time in this event, so a comparative study of various automotive systems is taken as our approach. With such an approach, engineers can come up with the best possible product for the society. We are also planning to conduct a customer needs survey to improve the vehicle further more. Anything being done for the first time, few difficulties are sure to come. Further improvements and a detail design of all other systems of the vehicle will lead to competitive vehicle. We hope to come with the best possible final product so that we will be one of the noticeable competitors in this year's competition.

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