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
- Maneuvrability
- 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:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Front</th>
<th>Rear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension type</td>
<td>Double wishbone</td>
<td>H-arm</td>
</tr>
<tr>
<td>Wishbone material</td>
<td>A106</td>
<td>A106</td>
</tr>
<tr>
<td>CG Height</td>
<td>25”</td>
<td>13”</td>
</tr>
<tr>
<td>Roll Centre Height</td>
<td>12.4”</td>
<td>12.8”</td>
</tr>
<tr>
<td>Suspension Travel</td>
<td>5.5”</td>
<td>5.5”</td>
</tr>
<tr>
<td>Track Width</td>
<td>55”</td>
<td>51”</td>
</tr>
<tr>
<td>Total Weight</td>
<td>660kg (Front=360/Rear=300)</td>
<td></td>
</tr>
<tr>
<td>Wheelbase</td>
<td>75”</td>
<td></td>
</tr>
<tr>
<td>Effective Wg of ATV</td>
<td>840kg (Front=331kg/Rear=510kg)</td>
<td></td>
</tr>
</tbody>
</table>
Based on above parameters, Suspension system was designed and analyzed with the help of Lotus Software and Solidworks 2016.

2.1 FRONT SUSPENSION DESIGN
2.2 REAR SUSPENSION DESIGN

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.
Braaking Calculations :

**Static Axle Load Distribution (Ψ)**
Ψ = Static Rear Axle mass / total mass
Ψ = 360/660 = 0.54

**Braking Force (Bf)**
Bf = Total Vehicle mass * deceleration * g
   = 660 * 30.27 * 9.81 = 20044.2 N

**Brake Torque (Ts)**
Ts = Bf * radius of tyre / speed ratio between wheel and brake = 6013.26 Nm

**Brake Clamp Load(C)**
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})**
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 = \frac{v^2}{2g} * a_{avg}
  = \frac{4.76^2}{2*9.81} = 3.05 m

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.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brake Master Cylinder</td>
<td>Bore Dia = 0.6023m</td>
</tr>
<tr>
<td>Brake Caliper</td>
<td>Bore Dia = 60 mm  No of Piston = 1</td>
</tr>
<tr>
<td>Brake Fluid</td>
<td>DOT 3</td>
</tr>
<tr>
<td>Stopping distance</td>
<td>3.05 m</td>
</tr>
<tr>
<td>Max pedal Force</td>
<td>400N</td>
</tr>
<tr>
<td>Weight Transfer</td>
<td>F/R = 2550/3924</td>
</tr>
<tr>
<td>Static Rolling Radius</td>
<td>11&quot;</td>
</tr>
<tr>
<td>Friction Coefficient of road</td>
<td>0.7</td>
</tr>
<tr>
<td>Force Required by Caliper</td>
<td>20044.2 N</td>
</tr>
<tr>
<td>Simultaneous Locking</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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.

References: