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Design and Analysis of an All-Terrain Vehicle

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Abstract— *the main aim of this Technical Paper is to Design an All-Terrain Vehicle (ATV) which is safe from Drivers view complying with all the rules specified in BAJA SAE INDIA rule book 2019. Being familiar to the event, certain changes were made to enhance the overall design. The car's demand is majorly from off-road enthusiast, hence considering drivers ease was a huge design consideration. Driver Ergonomics and performance of the off-roader was one of the major changes incorporated this year. Making the vehicle lighter and durable was another important consideration. In order to implement these changes deep study of material science and vehicle dynamics were carried out. This study was done both analytically and by use of software. The calculations and material compositions along with the software analysis are briefly described in the paper below.*

Keywords— CVT – Continuously Variable Transmission, CV Joint – Constant Velocity Joint, KPI – Kingpin.

I. INTRODUCTION

The major motive of the design report is to have an overall view of the All-Terrain Vehicle complying with basic Driver Ergonomics, Vehicle Performance and Specifications etc. adhering to all the rules specified in the BAJA SAE International Rule Book 2019. In accordance with last years' experience, the designs were optimized and the concept of 'design for manufacturing' was incorporated.

II. ROLL CAGE & ANALYSIS

Design of a roll cage consists of numerous factors like material selection, size selection, and frame design and finite element analysis. These each step is elaborated further.

2.1 Material Selection:

The material used for this year roll cage is AISI 4130 (chrome-moly steel) i.e. chromium molybdenum alloy steel. This was selected on a comparative study on parameters like Availability, Cost, Weight and Strength. We compared this following parameter with other steel grades like AISI 1018 and AISI 1020. But AISI 4130 is quite best among them structure. The properties of this material are:

Table 1
Material Properties

Density (Kg/m^3)	**7850**
Tensile Strength (Ultimate) (MPa)	786
Tensile Strength (yield)(MPa)	748
Modulus of Elasticity(GPa)	210
Elongation (%)	16.10

2.2 Pipe Size Selection:

Last year we started using the primary and secondary pipe sizing method for roll cage. This year also we are using same method. Last year we had better results in weight reduction. This year we made some changes in pipe sizing. This year there were changes made in the diameter of the pipe considering the equivalency calculations as per rules:

Bending Stiffness =EI
Bending Strength = S_y*I/c

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Table 2
Equivalency

Parameter	AISI 1018	AISI 4130
Bending Stiffness (N-mm2)	2.76x109	3.54x109
Bending Strength(N-mm)	387.378x103	706.70x103

2.3 Frame Design:

The primary objective of the roll cage is to provide the driver safe driving conditions and a platform for all the various subsystems considering the harsh terrain and topography. The roll cage must have sufficient strength such that it can withstand driver weight, bump loads and engine and transmission load. Also providing minimum clearances while designing the chassis, great emphasis was put on the safety of the driver as well as on Driver Ergonomics.

The main goals that were kept in mind while designing of the chassis were:

- Factor of safety >= 1.2
- Overall chassis weight = 26kg
- Least additional members for strength and support.
- Maximum roll cage stability considering loading of the various subsystems.

2.4 Analysis Results:

The purpose of analysis is to determine the structural stresses induced in various conditions in the roll cage and their resulting deformations. Principle of Momentum conservation was used for analyzing various conditions.

2.4.1 Front Impact: (condition)

The vehicle was considered moving at a speed of 59.13 kmph. It was subjected to sudden impact on a rigid wall. The impulse momentum equation was used to calculate force of impact.

2.4.2 Rear Impact condition :

The rear impact test simulates the vehicle being rear-ended by another Baja vehicle, at a speed of 60 kmph. To make this test as realistic as possible, the front of the vehicle is resting against a solid wall.

2.4.3 Side Impact condition :

The side impact test simulates the vehicle being side impacted by another Baja vehicle, at a speed of 60 kmph.

2.4.4 Rollover:

The roll over test simulates the extreme case condition of the vehicle toppling over the certain height. The force was applied on the intersection of FBM and RHO members to achieve realistic results.

2.4.5 Brake Rotor:

Slotted design of Rotor was selected in order to reduce weight. According to those calculations effective radius of Rotor was decided. The two different effective radius are obtained for rear and front they are 95mm and 67.5mm respectively.

2.5 Material Selection of Rotor:

The parameters considered while selecting material for brake rotor are machinability, frictional property, hardness and resistance against rusting and wear etc. Accordingly, SS304 is selected complying with market availability and cost.

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Considerations:
Ambient temperature: 30˚C
Emissivity: 1

2.5.1 Pedal:

Over hanging assembly was selected considering driver comfort and position of steering system. Pedal was designed with pedal ratio of 6:1 to reduce driver efforts. Piston travel of master cylinder was also taken in consideration.

While calculating the heat flux n convection coefficient the vehicle stopping time considered is 1.25 seconds and Maximum Temperature Rise was during braking was examined.

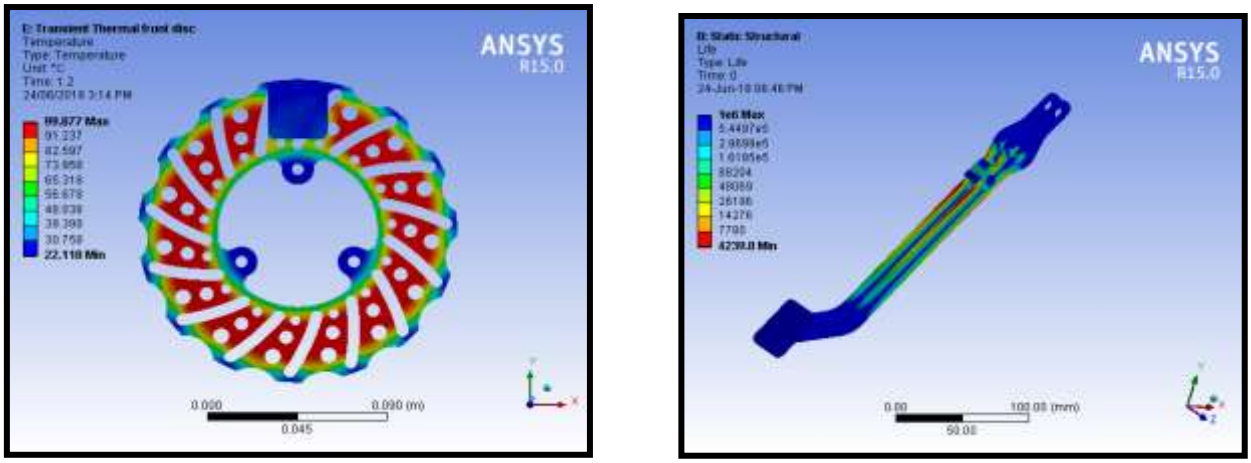

Figure 2: Brake Pedal simulation

III. CONCLUSION

The main aim of this Technical Paper is to Design an All-Terrain Vehicle (ATV) which is safe from Drivers view complying with all the rules specified in BAJA SAE INDIA rule book 2019. Being familiar to the event, certain changes were made to enhance the overall design. The car's demand is majorly from off-road enthusiast, hence considering drivers ease was a huge design consideration. Driver Ergonomics and performance of the off-roader was one of the major changes incorporated this year. Making the vehicle lighter and durable was another important consideration. In order to implement these changes deep study of material science and vehicle dynamics were carried out. This study was done both analytically and by use of software. The calculations and material compositions along with the software analysis are briefly described in the paper below. The designs of components are the safe and durable.

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