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DESIGN AND FABRICATION OF A ROLL-CAGE OF AN ELECTRIC ALL TERRAIN VEHICLE

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Abstract: -
This Paper aims to design and fabrication of a roll-cage of an electric all-terrain vehicle made up of Circular cross section pipes. Modeling and Analysis are performed using Software i.e catia according to the rulebook provided. The maximum deflection is determined by performing static Analysis with consideration to position of motor and battery position, braking System, steering system, seat position and many more. The FEA results are verified by comparing with analytical calculations. Considering these results modal is modified.

Keywords: - *FEA, Model, Optimization,* Analysis, Chassis.

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1.INTRODUCTION:

Now-a-days there is increase in Pollution all over the world and the main factor responsible for this is the harmful gases leaving from the Automobiles. Also there is a growing demand for fossil fuel like petrol and diesel to power the automotive and other needs of human. Due to excessive use fossil fuels are being depleted further the level of pollution from vehicle is increasing day by day. All these factors are responsible for various problems in human such as Headache, stress, reduced performances. To minimize all these Problems there is a need to explore alternative in place of fossil fuel powered vehicle. Battery powered vehicles are not so popular in India as they need frequent charging, small range of distance travelled in single charging, small range of speed and short battery life. To explore these ideas to students and to increase the focus on this research, the Society of Automotive Engineering started competitions in which students have to design and Fabricate the buggy which will be powered electric Battery.

2.Design Methodology:

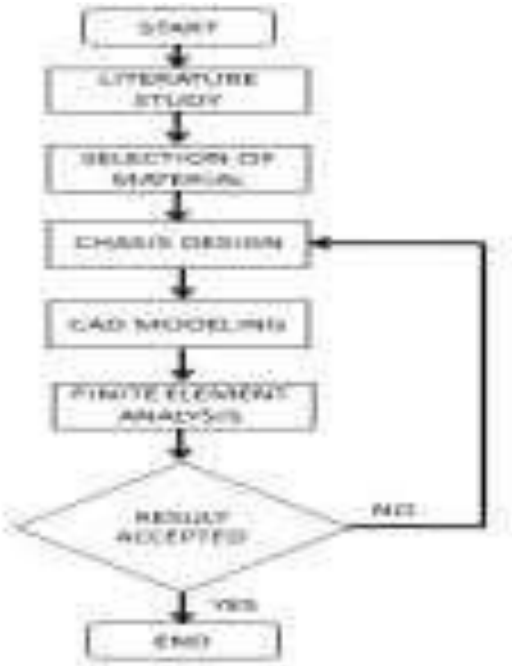


FIG 1 FLOW CHART : PROCESS METHODOLOGY

2.1. Selection of Material:

The material selection is a key factor while determining the strength of vehicle. According to the constraints of event the material should not be mild steel. Thus we had to look for alternative material. The materials considered are AISI 1018,low carbon Steel. This material was chosen because it's cost is relatively low and it is readily available. Moreover, it meets the requirements mentioned by SAEINDIA. There are many different categories of steel, and carbon steels are one such category that contains 0.12 to 2% carbon in them. The steel gains hardness and strength with heat treatment when the carbon percentage content increases; however its ductility is reduced.AISI 1018 carbon steel is a free machining grade that is the most commonly available grade around the world. Although its mechanical properties are not very unique, it still can be easily formed, machined, welded and fabricated.

The chemical composition of AISI 1018 carbon steel

Element	Content (%)
Manganese, Mn	0.60-0.90
Carbon, C	0.15-0.20
Sulfur, S	0.05 (max)
Phosphorous, P	0.04 (max)
Iron, Fe	Balance

The physical properties of AISI 1018 carbon steel

Properties	Metric	Imperial
Density	7.87 g/cm3	0.284 lb/in3

Mechanical properties of AISI 1018 carbon steel

Properties	Metric
Tensile strength	440 MPa
Yield strength	370 MPa
Modulus of elasticity	205 GPa
Shear modulus (typical for steel)	80 GPa
Poisson's ratio	0.29
Elongation at break (in 50 mm)	15%
Hardness, Brinell	126
Hardness, Knoop (converted from Brinell hardness)	145
Hardness, Rockwell B (converted from Brinell hardness)	71
Hardness, Vickers (converted from Brinell hardness)	131
Machinability (based on AISI 1212 steel. as 100 machinability)	70

2.2. Chassis Design:

The chassis can be called as skeleton of a vehicle besides its purpose being seating the driver, providing safety and incorporating other sub systems of the vehicle. Thus while designing we had to consider the driver and batteries weight as the major load acting on the chassis thus to support this load we have equipped a structure by two cross members. To achieve greater stability we maintained.

To begin the initial design of the frame, there first must be set some design guidelines. These include not only design features and manufacturing methods, but also the tools to be used in the design. From that point, the areas of the design that may show weakness or high loading should be analyzed for stress concentrations should be identified for analysis.

2.3. CAD Modelling:

Initial sketches were drawn considering the static load, dynamic load, load due to motor torque and braking torque.The new design was then modeled on catia and later analyzed on catia also.

Roll cage structure

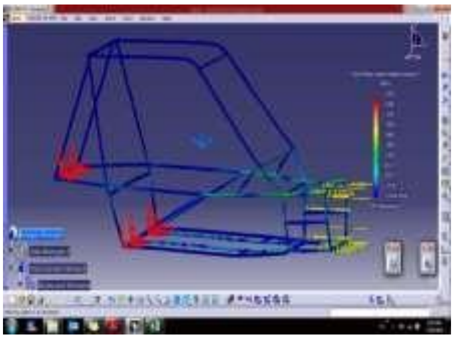
3. Finite element analysis:

The finite element analysis (FEA) used numerical method or often known as finite element method (FEM) that can be applied to approximate solution for an engineering problem. The approximate solution is obtained by idealized a product model by splitting it into as many small discrete pieces called finite elements or more commonly known as elements, which are connected by nodes. This dividing process is known as mesh generation. Each of the generated elements has exact equations that define how it reacts to certain load. Hence, accuracy of the solution can be increased by refining the mesh generation.The main criteria in analysis are factor of safety, even stress distribution and the maximum stress induced. Loads are placed on wireframe model of the frame at the critical points to simulate the amount of force that the Vehicle would undergo from its own weight and the Driver in the Event of Collision. Analysis is conducted by use of Finite Element Analysis FEA on ANSYS Software. A 4-node quadrilateral (Quad4) shell type element is used while developing the mesh to model the hollow tubing.

3.1. Analysis:

3.1.1. Front impactor the static frontal impact analysis: -

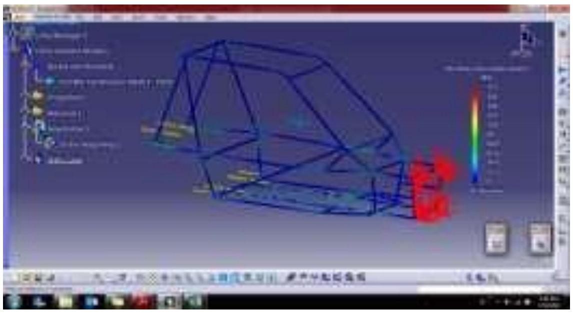
Deceleration of 10 G's was assumed for the loading which is equivalent to a static force of 26,698 N (equivalent to 6000 lbf) load on the vehicle, assuming the weight of the vehicle is 509.5Kg (1123.26 lbs.). Load applied: 26698 N/m^2 on front corner Constraints: ALL DOF's=0 on Rear corner points Note: Here we applied load of 10G. The research found that the human body will pass out at loads much higher than 9 times the force of gravity or 9 G's. A value of 10 G's was set as the goal point for an extreme worst case collision.



frontal impact analysis

3.1.2 Rear Impact: -

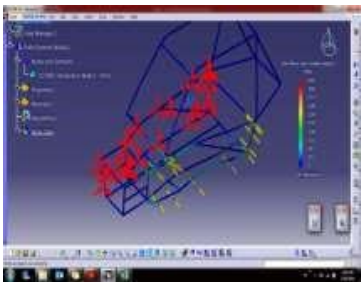
In this analysis a load of 5G was applied on rear corners by keeping front corners Constraint. Load applied 14000N/m^2 on rear corners Boundary conditions: All DOF's =0 on Front corner points.



Rear Impact

3.1.3 Side impact:

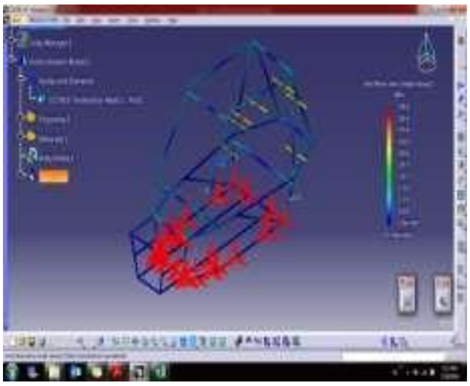
Side impact occurs mostly when a Baja vehicle collides other side ways. In side impact a load of 5g is applied on side impact members by constraining base and opposite side. Load applied on side members 14000N/m^2 Constraints: Assuming vehicle at static Opposite side impact members ALL DOF's =0



side impact

3.1.4 Roll over:

Roll over mainly occurs at time of cornering.RHO and FBM are subjected to loads. A load of 3.5G is applied RHO and FBM junction. Loading F=7000 N is applied on top front points. Boundary conditions: ALL DOF's =0 on all key points of bottom members



Roll Over

3.1.5 Front bump:

The next step in the analysis was to analyse the stresses on the shock mounts caused by a 5 g load on the shock mounts. The loading was applied to the 2 shock mounts in the horizontal shock hoop in the front of the vehicle. Loading f=2000N is applied on shock mounts Constraints: All DOF's=0 at rear wheels and opposite front wheels.

3.1.6 Rear bump:

The next step in analysis was to analyze the stresses on the shock mounts caused by a 5g load on rear shock mounts. The loading was applied to the 2 shock mounts in the horizontal shock hoop in the rear of the vehicle. Loading F=2500N in applied on rear shock mounts. Here for loading we consider weight of driver and vehicle.

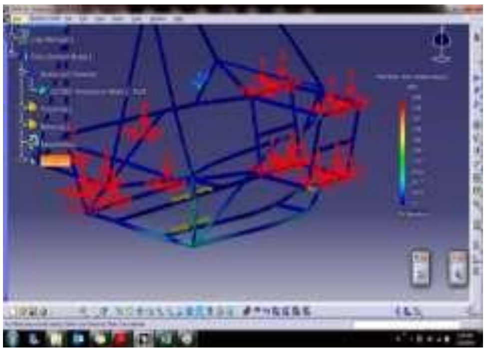


fig -Front bump and Rear bump

4.Conclusion

From the theoretical Calculations and Software Analysis results it is seen that the stresses obtained are within the material properties of Steel AISI 1018, and also a comparison is made when 4130 Chrome Moly Steel is used. Hence AISI 1018 material has been consider as it was an economically viable option.The usage of CATIA was invaluable to the design and analysis of the frame and suspension for ATV. The finite element analysis gave a very accurate prediction of where failure would occur in this situation. This prediction was validated in an actual rollover occurrence. Even though a fix was unable to be implemented in this frame design, the findings from the finite element analysis and the actual failure will allow future designers to integrate a solution tothis problem into their design from the beginning

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