Design and Simulation of F-1 Car Chassis

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Abstract - Hybrid Vehicle Challenge is an International level competition organized by the Imperial Society of Innovative Engineers (ISIE) to test student analytically and technical skills in designing and analyzing a race car chassis from all over India. There are different types of chassis; we choose the SPACE FRAME chassis in our project. This paper aims to showcase modeling and simulation of formula one car chassis frame. According to the rule book provided by ISIE solid works design software is utilized for the modeling the chassis. Analysis of the model is done on Ansys workbench. The Analysis results are exhibited. Based on the Numerical results, prototype of the chassis frame is made which intern helps us to fabricate the same.

Key words - Designing, FEA, Total deformation, Equivalent stress.

I.INTRODUCTION [1] [2]

Chassis is the supporting member for all the load operator, engine, brake system, fuel system and steering mechanism thus it should have adequate strength to protect the driver in the event of on impact. There are four types of chassis Frame Ladder Chassis, Tabular Space Frame, Monocoque and Backbone. We choose space frame in this study. In design of a chassis different modes of analysis are done like finite element analysis, static and dynamic analysis, forces acting on truss, torsional vibration, etc. The aim of the study is that the driver compartment remains safe during frontal, rear and side impact. The load / force act on front, back, side, top. The safety of the driver is achieved either by using high strength chassis against the applied load. The chassis is constructed by carbon fibre tubing with minimum dimensional and maximum strength. The ISIE organization manual restricts the vehicle weight, shape, size, and dimension. Circular cross-section is employed for the chassis development as it helps to overcome difficulties as increment in dimension rise in the overall weight decrease in the performance due to reduction in acceleration.

II.OBJECTIVE

The main objective is to select material for chassis frame. The materials for building chassis is selected by considering the following aspects.

- Chassis frame construction is suitable for driver safety.
- Determination of the maximum stress concentration area.
- High strength to weight ratio corrosion resistance.
- High stiffness and strength

III.DESIGN REQUIREMENTS [3] [4]

Before starting with the design of the chassis it is important to consider the driver ergonomics for the better comfort and hence better drivability. Hence following parameters are decided according to given constraints and requirements like width, length, height of chassis. ISIE organized as Asian level student formula race car competition. The Chassis frame, crush zone, driver leg compartment, driver's seat compartment and all other portions of the chassis are shown in figure 1. The table 1 gives the major dimensions of the race car.

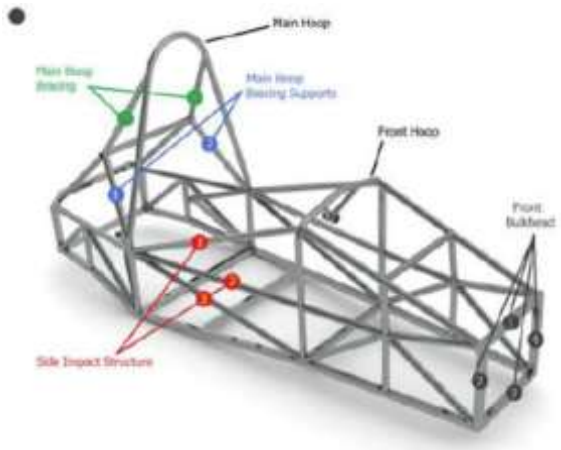

Figure 1: **Different Zones of Chassis frame**

Table 1: Specification of Chassis frame

Parameters	Dimension
Total length of the chassis frame in mm	1900
Total height of the chassis frame in mm	800
Width of the chassis frame in mm	846.9
Length of crushing zone in mm	300
Length of front hoop in mm	455.9
Length of driver's seat Compartment in mm	1030
Length of rear hoop in mm	700
Mass of the chassis frame in Kg	15
Outer diameter of pipe in mm	40
Inner diameter of pipe in mm	36

Methodology:

Finite element simulations of chassis design involve essentially three basic steps.

- Pre-processing
- Analysis
- Post-processing

4.1. Pre-processing

For modeling and analysis of chassis, the preprocessing step is one of the most crucial steps as it is necessary to develop appropriate finite element models. Pre-processing of the same requires a 4-step set-up procedure, Modeling, material selection, element property, and boundary conditions.

4.1.1. Modelling [5]

Modelling of the chassis is done by Solidworks 2016 software. The base of the chassis frame with proper dimensions is constructed using 3-D sketch tool. Then the crushing zone, front hoop, driver's leg compartment, driver's seat compartment and rear hoop with dimensions are created by selecting different planes. Weldment tool is used to convert the wire frame model into a pipe shaped chassis model. The created chassis model is shown in figure 2, 3 & 4. This modeled chassis is exported to the Ansys Work bench for analysis.

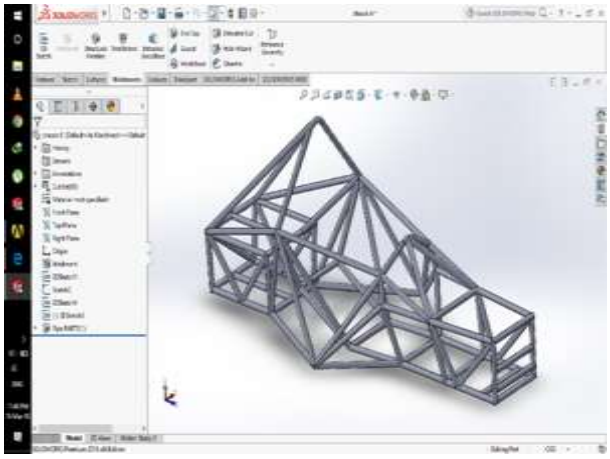

Figure 2: Chassis Model created by using Solidworks

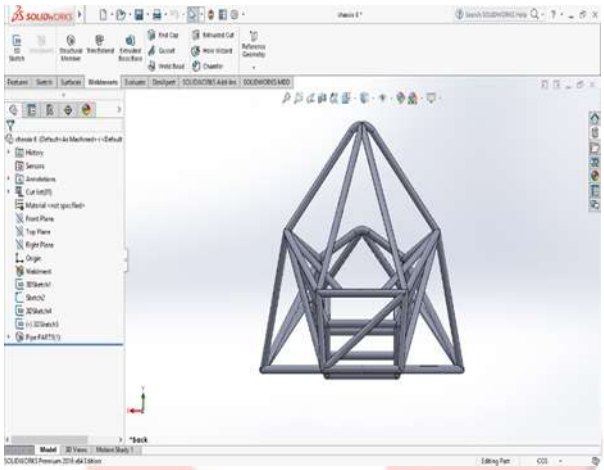

Figure 3: **Front view of chassis model**

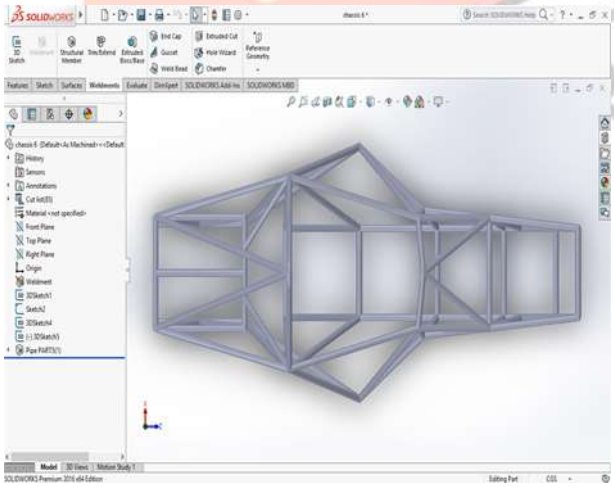

Figure 4: Top View of Chassis Frame

4.1.2. Material Selection [5]

Material selection of the chassis frame plays an important role in providing desired strength, stiffness, torsional rigidity and reliability of the vehicle. The material used for chassis design is carbon fibre The properties of different materials are given in Table 2.

TABLE.2 Material Comparison [4]

Physical Properties	Stainless steel	Gray cast iron	Carbon fibre

Tensile Yield strength MPa	280	0	2300
Density kg/m^3	2700	7200	1550
Young's Modulus GPa	193	410	228
Thermal conductivity W/m-k	17	46	21-180
Tensile ultimate strength MPa	310	240	3600
Poisson's Ratio	0.265-0.275	0.26	0.27

4.1.3. Meshing

Meshing is the most important part of the computer simulations, because it is responsible for drastic changes in results. We use triangular surface masher to mesh the entire chassis structure. The meshed chassis frame is shown in figure 6. As a result, 439813 Nodes and 226947 Elements were created.

By studying following properties carbon fibre is selected because:

- Carbon fibre has high strength to weight ratio and rigidity.
- It has high corrosion resistance, fatigue resistance, good tensile strength.
- It also has high thermal conductivity and light in weight.

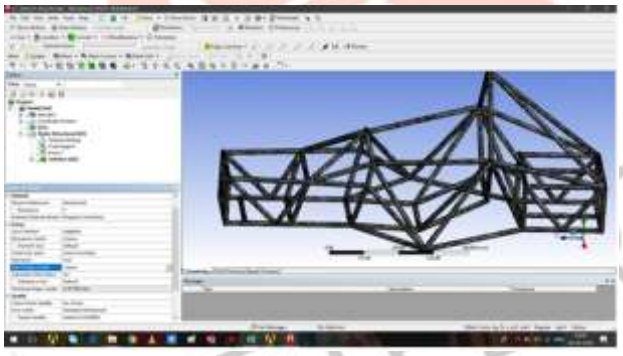

Figure 5: Meshed Chassis Frame

4.1.4. Boundary Conditions [9][10]

Boundary Conditions refer to the Constraints and Loading. To Simulate the analysis all degree of freedom at the tail end of the chassis is arrested. For a perfectly inelastic collision, energy transferred is

$DE = ½ (M1M_2/M1+M2)(u2-u1)^2$

where M1 and M2 are masses of two vehicles and u1 and u2 are corresponding velocities. Assuming M1=M2=810kg and u2=0 (vehicle at rest), $DE = 1/4\ m1u1^2$ & F=DE/t where t=100ms

Then, F= [.25 x 810 x (43.83)^2] / [1] = 389016.45 N

Hence, a frontal impact force of 64840 N was applied at 6 points on the frame. The back of the frame was completely constrained.

4.2. Analysis [8]

Analysis step involves the Newton-Raphson Residuals method. It performs the static analysis of three-dimensional chassis structures.

4.3. Post-processing

The post-processing result data including the real time animation of stresses, strain energy, Total deformation, directional deformation, process simulation results and frequency. The maximum deformation occurs is 48.17e-0.003m. The equivalent stress found is 4080.6 Mpa.

IV.RESULTS & DISCUSSION

The modal analysis and static structural analysis on the F1 race car chassis frame was carried out. The results of the static and modal analysis revealed that the location of maximum total deformation, maximum stress and maximum strain. The results shown in fig. No 7 to 9 proved that deformation occurs only in the crush zone and thus the F1 race car chassis is safety to the driver. So, the chassis frame can be fabricated to the selected dimensions.

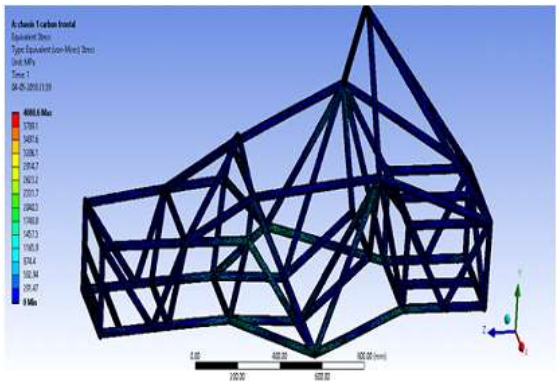

Figure 6.1: Equivalent stress with frontal impact.

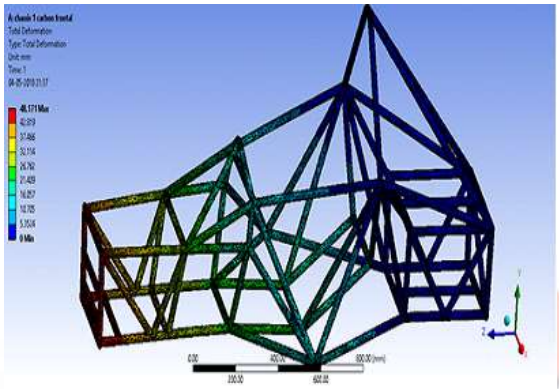

Figure 6.2: Frontal analysis with total deformation.

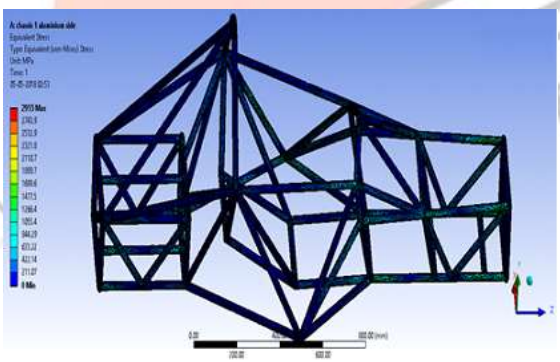

Figure 7.1: Equivalent stress due to side impact.

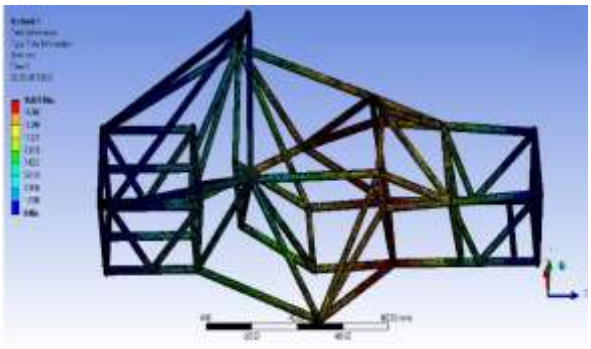

Figure 7.2: Total deformation due to side impact.

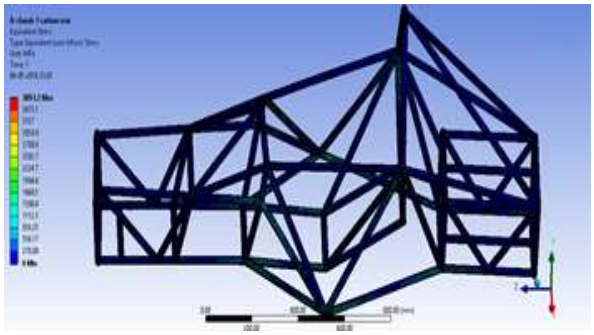

Figure 8.1: Equivalent stress with rear impact.

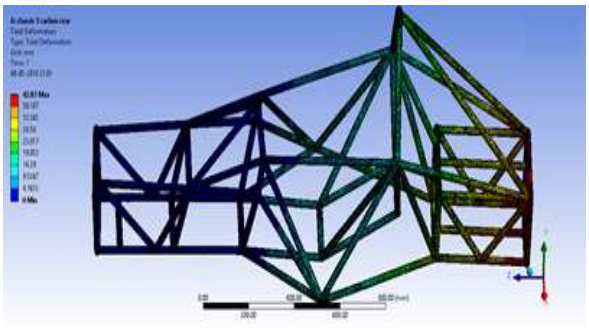

Figure 8.2: Total deformation due to rear impact.

V. CONCLUSION

Static analysis using ANSYS software was successfully carried out. From the overall analysis the maximum deformation occurs when the back end fixed and front end applied with force and is 48.17 mm. The maximum equivalent stress is 4080.6 N/mm^2.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

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