

Design and Analysis of a Space Frame Tubular Chassis for a Formula Student car

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ABSTRACT: A chassis is one of the most important component of an automobile. It is the component which holds all the other components together and all the forces acting during an automobiles motion are transmitted either directly or indirectly into it. Amongst different categories of chassis a space frame type is chosen. The chassis is designed for a Formula Student vehicle and thus needs to be strong, stiff and lightweight. Computer Aided Modelling is done on a popular CAD software CATIA V5. The design of the chassis is guided by different rules set up by the Formula Society of Automotive Engineers(FSAE). Different design iterations are carried out to minimize weight, maximize stiffness and improve packaging of all the components being mounted on to the chassis. Ergonomics is also considered as one of the most important design aspect. Analysis of the final CAD model is done on ANSYS APDL. Different load cases are considered during analysis to ensure that the chassis can endure the forces acting during the vehicles motion.

KEYWORDS: Space Frame, Truss, Stress, Deflection, FEA

I. INTRODUCTION

A space frame chassis is one of the most important types of chassis used in automotive applications. It is so popular because of the design freedom that comes along with it. It is basically based on the principle of working of a truss. A truss is a triangular structure in which all the acting loads are either tensile or compressive. Based on this a space frame chassis has multiple trusses which makes it very strong when subjected to varying loads. Many automotive experts have shown their inclination towards space frame chassis being used in high performance race cars.

Formula Student competitions are being held worldwide which gives students an opportunity to design, manufacture and test a miniature version of a Formula1 car. A rule book provided by the Formula Student of Automotive Engineers(FSAE) is used as reference before and while designing the chassis. These rules are provided to ensure safety of the students driving and testing formula student cars.

II. DESIGN PHILOSOPHY

Before starting with the design of the chassis it is important to consider the driver ergonomics for better comfort and hence better driveability. An ergonomic apparatus was designed in order to decide the final dimensions of different parts of the chassis such as cockpit width, cockpit length, height of steering, length of chassis etc.

The apparatus was designed on CATIA V5 and was then manufactured and different drivers of varying physical built were made to sit inside it. Feedback was taken from each driver in order to get dimensions for the most ergonomic chassis. Fig 1(a) shows the CAD model of the ergonomic apparatus.

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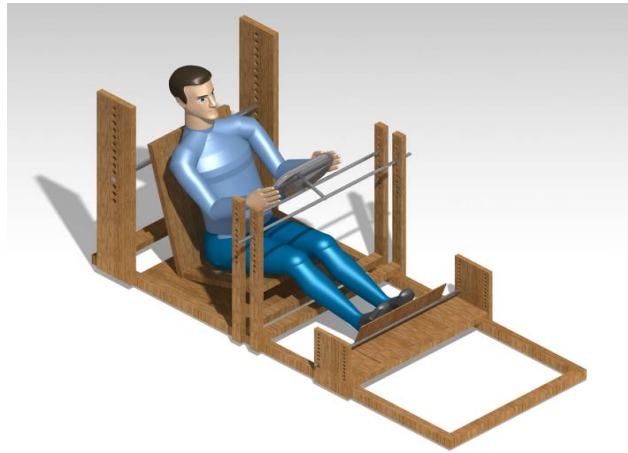


Fig 1(a) CAD model of the ergonomic apparatus

Based on this design the apparatus is manufactured and different drivers are made to sit in it and final dimensions of the chassis are finalized. This is shown in Fig 1(b).



Fig 1(b) Manufactured model of the apparatus

Final dimensions of the chassis are as follows :

- Chassis length : 2200 mm
- Cockpit width : 658 mm
- Height of front hoop : 558 mm
- Height of main hoop : 1119 mm

The material chosen for the chassis was chromoly 4130 because of its less density and excellent weld ability.

III. COMPUTER AIDED MODELLING

After finalization of the dimensions of the chassis the modelling was started in CATIA V5. Different design iterations were carried out keeping in mind the rulebook, packaging and mounting of all the components. Figure 2(a) shows the final design of the chassis.

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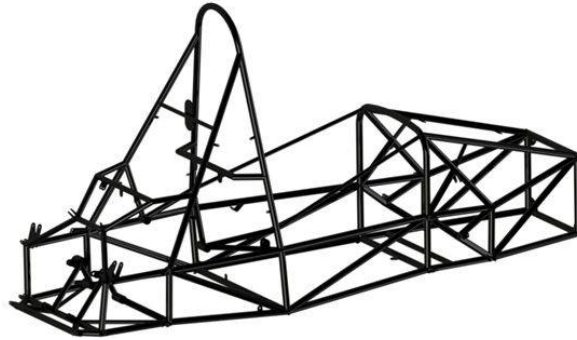


Fig. 2(a) Final Design of the chassis

Figure 2(b) shows the engine assembly mounted on to the chassis. It consists of the engine, intake manifold, exhaust manifold, cooling system and the lubrication system.

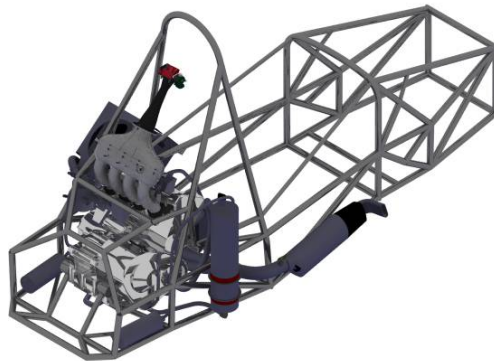


Fig. 2(b) Engine assembly mounted onto the chassis

Figure 2(c) shows the transmission assembly mounted onto the chassis which consist the differential mounts, pneumatic tanks etc.



Fig. 2(c) Transmission assembly mounted onto the chassis

Fig 2(d) shows the vehicle dynamics assembly on the chassis which consists of the a arms, dampers, pedal assembly etc.

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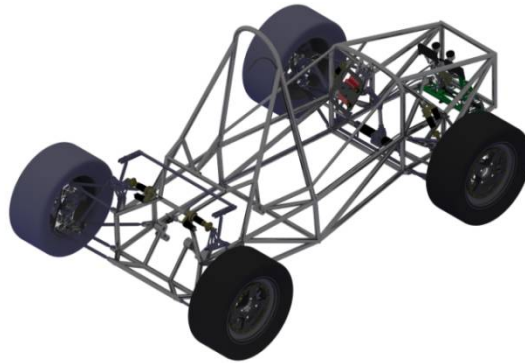


Fig. 2(d) Vehicle Dynamics assembly mounted onto the chassis

IV. COMPUTER AIDED ANALYSIS

After the design was done with all the mountings of different components finalized the chassis was analysed in ANSYS APDL. The model was imported into the software and different boundary conditions were applied to test its durability during testing of the car.

Boundary Conditions :

- Forces coming from the suspension were applied
- Drivers weight was applied
- Engine weight was applied
- Forces coming from the differential were applied
- Engine was modelled in the form of rods of high stiffness because the engine also takes the loads and resists deformation of the chassis.
- Forces were applied at seat mounting points, safety harness mounting points, engine mounting points and differential mounting points.

V. RESULTS AND DISCUSSIONS

After all the forces and boundary conditions were applied plots of stress and deflection were studied and conclusions were made about the design.

Fig. 3(a) shows the stress plot which depicts different stress locations on the chassis. The idea is to keep the maximum stress at any point on the chassis below the yield strength of the material being used for the analysis of the chassis. The maximum stress observed in the chassis is around 215 Mpa. In this case the design is safe from the stress point of view because it quite less compared to the yield strength of the chosen material chromoly 4130 steel which is around 500 Mpa.

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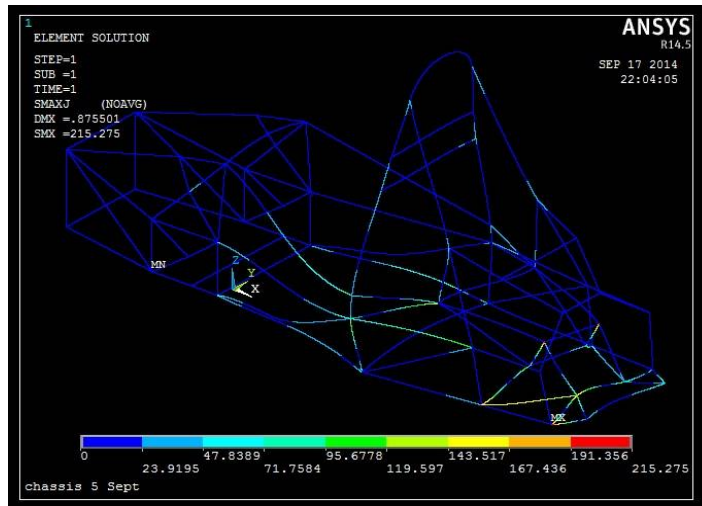


Fig. 3(a) Stress plot of the chassis

The second factor which is considered is the maximum deflection that occurs in the chassis, it is safe to say that if its below 1mm the design is very safe. Figure 3(b) shows the deflection plot of the chassis. The maximum deflection observed is around 0.87mm which can be easily considered safe.

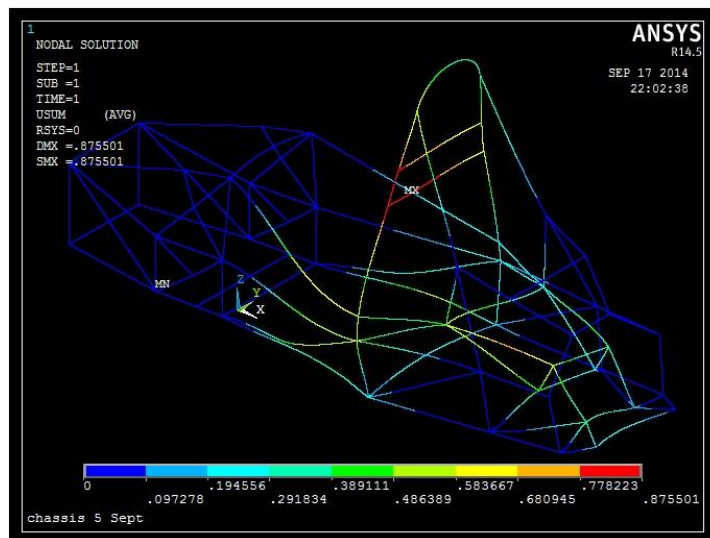


Fig. 3(b) Deflection plot of the chassis

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Figure 4 shows the final assembly of the car with all the components mounted onto the chassis



Fig. 4 Final assembly of the car on the final chassis

VI. CONCLUSION

The final design of the chassis with proper analysis had very good properties. With a maximum stress of 215 MPa and a maximum deflection of 0.87 mm the design can be considered very safe and thus can be manufactured for an actual Formula Student car.

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