Review on Design, Static and Dynamic Analysis of FSAE Chassis

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Abstract - *This paper reviews the developments in a FSAE race car chassis in latest years according to FSAE rule books. In a car, chassis was considered to be the backbone of any vehicle. All the loads, forces acting on a car are and transmitted to ground through wheels and tyres with the help of chassis. Chassis act as the main supporting unit in a vehicle. A chassis needs to be as light as possible for best performance while considering driver safety. Chassis also act as the mounting point of the components in a proper place so that the vehicle was properly balanced. Torsional rigidity should be high to avoid failure of the car and the chassis must be strong to resist all the bending forces acting on it. Design and analysis of the sub-systems components and the structural frame layout were performed using CAD/CAM/CAE software's such as Solid Works, ANSYS. This analysis ensures all above points that are studied and stated in this paper.*

***Key Words*: light weight, stiff, torsional rigidity, solid works, ANSYS etc.**

1. INTRODUCTION

SUPRA SAE a student design competition organized by the Society of Automotive Engineers which provides an opportunity to the engineering students for enhancing and implementing their practical knowledge by designing and fabricating formula vehicle in order to compete with other students and teams which are participating in the event. The SAE competition is consisting of static and dynamic event where they judge vehicles based on various parameters like conforming rules with performance of vehicle, team work and vehicle compliances.

To make a good chassis several important points are to be taken into considerations while designing a chassis

- Light Weight - Chassis should be as light as possible to increase acceleration as weight of the vehicle directly affects the acceleration and chassis comprises of most of the vehicle weight
- Material selection - Appropriate material selection for the chassis was also a main criterion. Materials have different properties so proper selection is required for optimum strength of chassis and safety of the driver.
- Rigidity - To maintain a proper control over suspension geometry proper rigidity of chassis is required. To keep all four of the wheels firmly in contact with the ground.
- Safety - Safety of the driver was also a crucial criterion for designing, using analysis the designed frame was validated to ensure the best possible geometry for safety and performance.

2. LITERATURE REVIEW

[1] Did study regarding selection of type of chassis.

There are different types of chassis like ladder, backbone, spaceframe, monocoque etc. Out of these spaceframe chassis was selected because Backbone chassis does not provide productive shielding from side impact and offset crash. As the chassis rails are near together to appropriate in the middle of the seats i.e. the dropping of stiffness. Production expensive and complex. Ladder frame shape could not be chosen since absence of diagonal bracing, as of which it can simply be distorted across its length. Additional member is attached to make it extra stiff and extra rigid with that there is rise in weight. Also, it takes time to align and weld all the discrete members together. Monocoque was shut out from design, because can't make changes to once it made. As compare to tubular based shape fine material is use in monocoque chassis and because of fine material it is easily buckle. It is expensive and not easy to repair.

[2] Studied use of different materials for base material of chassis. steel was used as it was easily available and had low cost but steel had properties inferior to other materials as shown in table below Considering the different properties it was decided to select AISI 4130 chromoly as the base material for the chassis only disadvantage of AISI 4130 is high cost which was a factor to consider while selecting but chromoly costing little higher had excellent properties compared to other materials.

Table -1: Properties of Materials: -

Properties	AISI 1020	AISI 1010	AISI 1018	AISI 1080	AISI 4130
Density(g/cm3)	7.87	7.72	7.8	7.7	7.85
Youngs modulus (GPa)	210	200	210	200	210
Brinell Hardness	119	105	120	174	200
Yield Strength (MPa)	350	305	370	375	460

Ultimate strength (MPa)	420	365	440	965	670
Poisons Ratio	0.29	0.27	0.29	0.27	0.30
Cost per Kg	65	55	65	125	150

[3] Studies about the basic design considerations such as driver safety and ergonomics. Driver gets a maximum safety through the roll cage so we have selected the material which have high strength to weight ratio, as well as in minimum weight there is more strength to roll cage. Ergonomics stands for man and machine relationship. It means that we have to design a car as per the driver's requirement. Designing of the roll cage must be started from the base of the roll cage. From that we can get an idea about the overall length of the roll cage, position of driver and position of other sub systems on roll cage.

[4] The perspective of seating location for the occupant i.e., for 95th male percentile, or 5 percent female percentile, is provided in FSAE Rule Book. Also dimensions for driver cockpit design is also provided in the Rule Book.

[5] Studied analysis that are carried on the chassis design using CAE software's. Finite element analysis method is used to calculated different stresses and forces acting on the chassis. FEA method is breaking down a larger component into smaller parts using meshing and calculating forces on each smaller part.

Different analysis

1. Front Impact: In the front impact test, it is considered that the vehicle must be collided with a stationary body. In order to simulate this condition in ANSYS, force is applied on front portion of the vehicle and suspension points are constrained in all directions.

2. Side Impact: The side impact test is carried out by applying force on the side impact members constraining the suspension points.

3. Rear Impact: In rear impact test, the vehicle is assumed to be stationary and other vehicle hits from rear. The force is applied on the rear end of the vehicle constraining the suspension points.

4. Torsional Rigidity: Torsional test is performed by constraining suspension mounting points and force of ±6kN was applied on both front wheels.

5. Bending Stiffness: Bending stiffness is also termed as the flexural rigidity of the member and also termed as capacity of structural members to resist bending. It is defined as moment required to produce unit rotation, and it depends upon the elastic modulus (E), moment of inertia (I), and length of the member.

6. Load Transfer: In load transfer test acceleration of 9800mm/s^2 is applied in positive X-direction and acceleration due to gravity of -9800mm/s^2 is applied in negative Y-direction. All the suspension points are fixed and Total deformation, Axial Force, Direct stress and combined stress is calculated.

[6] In this Study CAD and Finite element analysis method was used to design and analyze the Formula Student Frame respectively. The chassis was designed in a creative using industrial design whose goal was to reach the quality of industrially produced products. For aesthetic as well as for better performance of the vehicle (aerodynamic, stability control, speed and acceleration) it was observed that the proper selection of outside shape and the dimensions and their compatibility with the system was a crucial factor. Various methods of manufacturing Formula Student chassis are described in the paper. Once the chassis was manufactured physically various rigidity test were performed on the chassis these include Torsional Stiffness and Bending rigidity. Subsequently Dynamic frequency analysis was performed on the chassis.

[7] Frame is defined as a fabricated structural assembly that supports all functional vehicle systems. This assembly may be a single welded structure, multiple welded structures or a combination of composite and welded structures. The chassis will be deformed depending upon the loads and the direction in which they act.

1. Longitudinal Torsion—created mainly by a cornering vehicle or bumps in the racetrack. It is the chassis' ability to resist deformation under this load that defines torsional stiffness.

2. Vertical Bending—Vertical bending is created by the weight of the drive and vehicle's components; these forces can be boosted by vertical acceleration produced.

3. Horizontal Bending—This deformation mode is caused by the centrifugal forces created by the cornering of the vehicle.

4. Horizontal Lozenging—occurs when the car deforms into a parallelogram-like shape, this is caused by the uneven or opposing application of force on the wheels on opposite sides of the car.

[8] Modal analysis is the study of the dynamic properties of structures under vibrational excitation. The field of evaluating the dynamic response of structures or fluids during specific frequencies is Modal analysis. In cars it is used to determine natural frequencies of vibrations. Higher the natural frequency better is the structure to sustain Modal analysis determines the mode shape (vibration shape) and frequencies for the particular mode shape of a structure for a free vibration analysis. Normal Modes Analysis, also called eigenvalue analysis or eigenvalue extraction, is technique

used to calculate the vibration shapes and associated frequencies that a structure will exhibit. It is important to know these frequencies because if cyclic loads are applied at these frequencies, the structure can go into a resonance condition that will lead to catastrophic failure. It is also important to know the shapes in order to make sure that loads are not applied at points that will cause the resonance condition. Modal analysis has been done to ensure that the natural frequency of the roll cage does not match the natural frequency of the engine.

3. CONCLUSIONS

Generally Objective for the chassis, increasing torsional rigidity and decrease weigh, deformation. The chassis must be powerful because Every critical component relies on the chassis either directly or indirectly. The driver of the vehicle also relies on the chassis for protection in the event of an accident. In this task, Tubular chassis initial design on solid works software and also structural analysis is carried out. Design should made according to FSAE Rule. Design is not easy procedure it takes several iterations to finalize the design. In analysis, applied Various type of static analysis like Front impact test, side Impact test, torsional rigidity, rear impact, on chassis. According to FSAE the torsional rigidity must lies between. In begin the torsional rigidity coming so low for that done little changes in chassis design. Material play important role in analysis after doing analysis on different material (AISI 1010, AISI 1020), AISI 4310 giving better torsional rigidity, Low Cost, better yield Strength than other material. By vary material the weight of the chassis also changes because little the chassis higher the acceleration. After so many trials, the results gained in this section show that the chassis will experience very minimal deflections under race conditions. This is also going to allow the chassis to perform at an ideal level in conjunction with the rest of the vehicle setup. Like any vehicle, the chassis is the backbone of the system. This dissertation covers the procedures that were used to successfully design and construct a functional chassis.

REFERENCES

[1] Dr. Steven Timmins, Corwin Dodd, Nicholas Geneva, Patrick Geneva, Cory Morris, "MEEG 402-010 Chassis Design Report", Feb 2017

[2] Srishti Shukla1, Shubh Agnihotri2 and R. R. Sahoo, "Design and Analysis of Formula SAE Chassis ", March 2016

[3] Pruthviraj Vitthal Wable, "Design and Analysis of FSAE Rollcage", Feb 2017

[4] FSAE Rule Book 2021

[5] Dr. A.J. Gujar1, Vinayak Vijay Ingavale2, Sourabh Milind Patil3, Suraj Sambhaji PanhalkarPiyush Ravindra Gat5, Amit Sanjay Shinde6, "Static structural analysis of Formula Student Space Frame", April 2019

[6] William B. Riley and Albert R. George, "Design, Analysis and Testing of a Formula SAE Car Chassis", Cornell University, 2002

[7] Shubham Thosar, Antriksh Mutha and S.A. Dharukar, "Structural Performance Analysis of SAE Supra Chassis", September 2017

[8] Rupesh Patil, Vinayak Chikkali "FEA Analysis of FSAE Chassis", July 2020

[9] Ravinder Pal Singh, "Structural performance analysis of Formula SAE car", Dec 2010

[10] Surve Aditya, Naik Vishal, Naikar Aditya, Mohd. Raees, "Analysis of FSAE chassis", March 2018

[11] D. LAVANYA, G. GURU MAHESH, V. AJAY, Dr. C. YUVARAJ,"DESIGN AND ANALYSIS OF A SINGLE SEATER RACE CAR CHASSIS FRAME", August 2014