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Design and Analysis of Formula - 3 Frame

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Abstract
The design of race car for the beginner cart competition involves more performance parameters then for regular racing. In addition to achieving high strength and stiffness for a very low overall weight, the car must be easily manufacturable and maintainable to stay within budget. In this an approach is presented on designing a lightweight hybrid race car chassis consisting of a fiber reinforced composite cockpit combining structural, esthetic, ergonomic and crash properties, and a tubular space frame engine compartment, meeting stiffness and strength demands while remaining easy to maintain and manufacture, thus keeping production cost low. Beginner cart is a small racing car, based on construction of the Formula Three. Due to security issues, there is a number of regulations that must be respected in the construction and design of this Formula vehicle. The frame is designed in the "PTC Creo 4.0" software, in which the structural analysis of the load using the finite element method is performed. Based on facted analysis, optimal conception of frame is suggested.

Keywords: beginner cart, chassis frame, design, FEA.

1. INTRODUCTION

Formula Three, also called Formula 3 or F3, is a class of open-wheel formula racing. The chassis frame has been used widely in varsity level formula race car. Due to its advantage of easy to be manufactured and easy to be repaired, space frame chassis is the most favourable choice for race car development of newly introduced varsity level of beginner cart competition.The chassis of an automobile is defined as frame supported on springs and attached to the axle that holds the body and engine of vehicle. Chassis is a French word and was initially used to denote the frame parts or basic structure of an automobile.

The conventional construction, in which a separate frame is used and the frameless or unitary construction in which no separate frame is employed. Out of these, the conventional type of construction is being used presently only for the heavy vehicles. While for the car same has been replaced by the frameless type or the monocoque chassis. The purpose is to design and manufacture tubular space frame chassis that should be strong enough to absorb the energy when front, back, side, torsional loads are applied.

In this project summarizes the design, fabrication and analysis processes of the chassis frame. The end product is then used in actual assembly of the race car together with the other components. Due to some tolerances in fitting and welding processes, the final chassis frame is modified and changed slightly throughout the fabrication process. The frame is designed in the PTC Creo 5.0 software. Ergonomics is also consideredas one of the most important design aspect. Analysis of the final CAD model is done on ANSYS WORKBENCH 17.0. Different load cases are considered during finite element analysis to ensure that the chassis can endure the forces acting during the vehicles motion.

2. THE CHASSIS

The chassis is possibly the most important part of any vehicle. Its main role is to provide the vehicle with a main structure which all other components can be fixed to a vehicle without body is called Chassis. The chassis must be rigid in both torsion and bending and must be able to resist twisting and sagging. The chassis must be able to accommodate and support all the components of the vehicle and any occupants and must absorb all loads without excessive deflection.

TYPE OF CHASSIS DESIGN

Ladder frame chassis

The ladder frame chassis was the earliest type of chassis used. It was widely used for the earliest cars until the early 60s. The design is, as the name suggest, similar to a ladder. There are two longitudinal rails running the length of the vehicle which are connected together by several lateral and cross braces.

Space frame chassis

The space frame was the next logical step up from the ladder frame. A space frame has a number of features that distinguish it from a ladder frame and add massive advantages. A perfectly designed space frame would have the tubular sections arrange so that the only forces on them are either tension or compression

Monocoque chassis

The Monocoque style of chassis is used by almost all car manufacturers today. A Monocoque is a one-piece structure that defines the overall shape of the vehicle. This type of chassis is very attractive to mass production as the process can be automated very easily. The structure also has very good crash protection as crumple zones can be built into the structure itself.

Backbone chassis

A backbone chassis is a simple style of frame that uses a central backbone running the length of the chassis that connects to the front and rear suspension attachment areas. The backbone usually has a rectangular cross section. The body of the vehicle is then placed onto of the structure. This type of chassis is used sometimes for small sports cars however it provides little or no protection against a side impact and so requires the body to be designed to accommodate this.

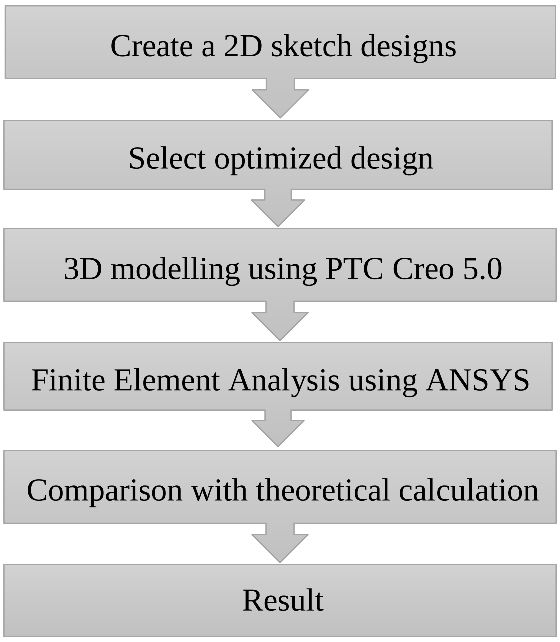
3. MATERIAL SELECTION

The selection of the material gave prime emphasis of being light weight and highly rigid and durable .AISI 4130 alloy chromium molybdenum (CrMo) steel is high strength material with very less weight. It is used in manufacturing of air craft and its cost is high based on the survey the Table 1 has the properties of various materials and the materials AISI 1018 was chosen for the chassis. This material has been selected by the following factors cost, availability, strength, machinability and durability.

SI. NO	Material properties	Material		
		AISI 1018	AISI 1020	AISI 4130
1	Density (g/cc)	7.87	8.03	7.85
2	Cost (Rupees)	450	490	680
3	Hardness (HB)	126	111	217
4	Ultimate Strength (MPa)	440	394.7	560
5	Yield Strength (MPa)	370	294.8	460
6	Machinability	60%	68%	70%

Table 1: Properties of materials

4. DESIGN METHODOLOGY



The methodology has been followed to the frame in Creo and analysis it in the ANALSYS software. The theoretical values are calculated and compared with actual values.

5. CAD MODEL

Modelling was done by using PTC Creo 5.0 software. Here the model is considered as surface body and thickness for the surface is considered as 3mm. the force that has been imposed downward to the structural model. The load is distributed uniformly and equally on the members below the driver's seat and engine compartment.

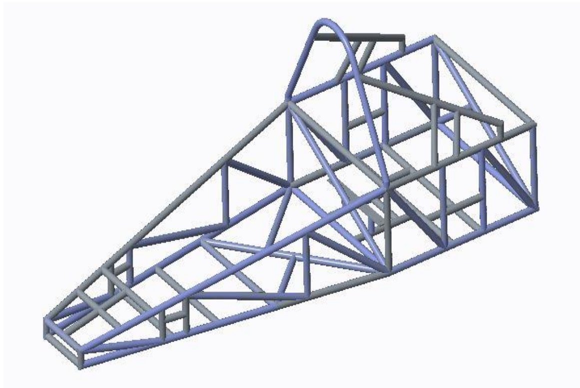


Figure 5.1 Orthogonal view

Dimension of frame	
Length	2.6375 m
Width	0.935 m
Height	1.0774 m

Table 2: Final dimensions of frame

The frame of vehicle is very important part, and, until design process of vehicles, it paid special attention, because it is loaded with very high loads (static and dynamic). Projecting and manufacturing represent big challenge, because many factors affect on its final version. Space frame (which is the most used kind of frame in Formula student vehicles) represent very complex tubular truss construction, on which we can notice, separate and define its main elements.

6. ANALYSIS

The safety and the strength of the chassis are important issues for its structure to meet the requirements, in which the structural analysis of the frame using the finite element method performed. Based on the structural analysis, optimal conception of frame is suggested.

Parameter	Value	Unit
Material	AISI 1018	
Kerb weight	250	Kg
Mass	97.041	Kg
Volume	1.233e-002	m^3
Total length	2.6375	m
Height	1.0774	m
Width	0.935	m
Young's modulus	2.e+011	N/m^2(or)Pa

Table 3: Frame Specification

RESULT AND DISCUSSION

Front impact analysis

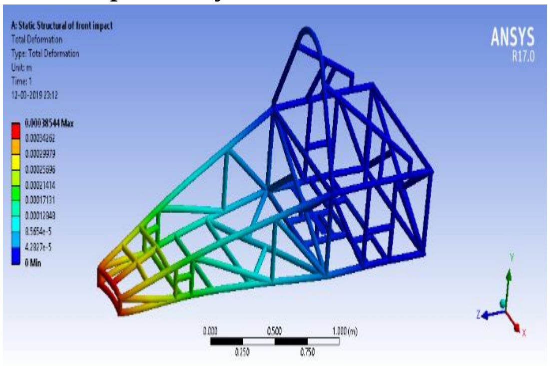


Fig 1: Total Deformation

From the consideration of above tabled properties of the static structural impact analysis were done and generated results are summarized as below.

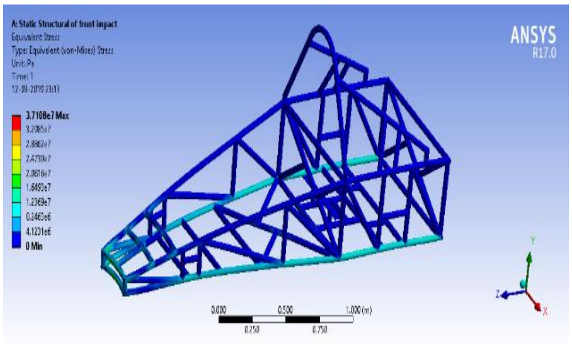


Fig 2: Equivalent stress

The applied impact load is 7500 N

Type of analysis	Total deformation	Equivalent stress
Maximum [Pa]	3.8544e-004	3.7108e+007
Factor of Safety	1.1859	

Side impact analysis

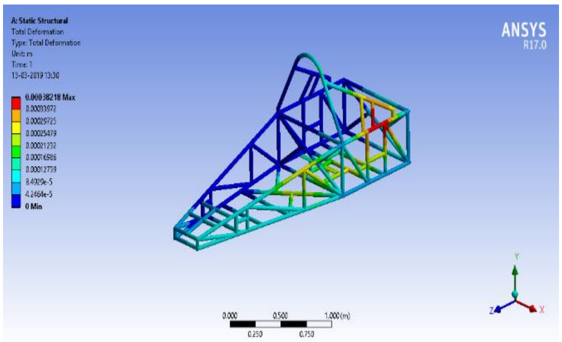


Fig 3: Total Deformation

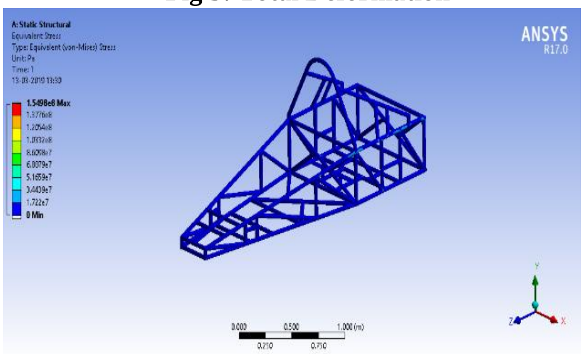


Fig 4: Equivalent Stress

The applied impact load is 7000 N

Type of analysis	Total deformation	Equivalent stress
Maximum [Pa]	4.1507e-004	1.9768e+008
Factor of Safety	2.857	

Rear impact analysis

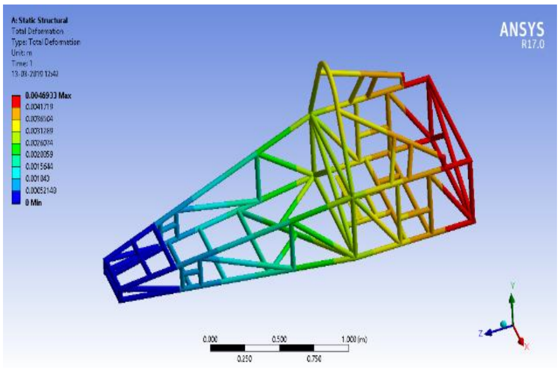


Fig 5: Total Deformation

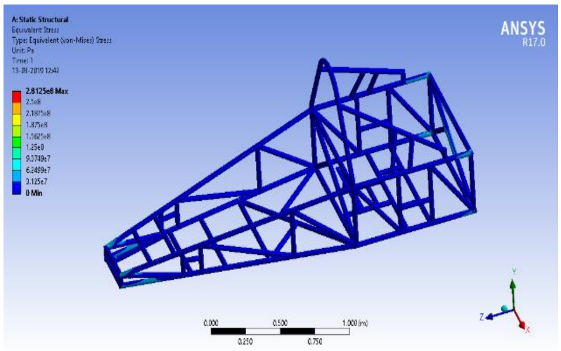


Fig 6: Equivalent Stress

The applied impact load is 8000 N

Type of analysis	Total deformation	Equivalent stress
Maximum [Pa]	6.0555e-003	3.6086e+008
Factor of Safety	1.22	

7. CONCLUSION

After all the forces and boundary conditions were applied plots of stress and deflection were studied and conclusions were made about the design. This paper focuses on the design, analysis and calculation of various components that is necessary for fabrication of a formula 3 frame. We have performed various types of static analysis and applied different loading conditions on the frame and it if found to be safe according to their factor of safety. We also learn how to select appropriate material for the safe design of frame. Successful analysis was perform on the frame of CAD modal using ANSYS WORKBENCH to determine, equivalent stresses, and total deformation results. The objective of the frame design was to satisfy these functions while meeting the beginner cart student regulations with special considerations given to safety of the driver, quality, weight, ergonomics and aesthetics.

8. REFERENCE

[1] Bhande Akshay S, et.al."Design and Analysis of Space Frame Chassis for Formula Student Race Car". International Journal of Engineering Research & Technology, Vol.7 Issue 06, June-2018.

[2] "AISI-SAE Classification of Steels". American Iron & Steel Institute, New York; SAE Standard J403f. Rule book of Steels page no: E-218, E-220, E-221 and E-221.

[3] Lavanya.D, et.al. "Design and analysis of a single seater race car chassis frame".International Journal of Research in Aeronautical and Mechanical Engineering.ISSN (ONLINE): 2321-3051. Vol.2 Issue.8, August 2014.

[4] Josh Carroll, et.al."Chassis and Impact Attenuator design for Formula Student Race car", International Journal of Engineering Research & Technology, Vol.7 Issue 06, August 2012.

[5] Miroslav Milojevic, et.al."Design and Analysis of Formula Student Frame". 9th International Quality Conference, June 2015.

[6] Apoorva Tyagi, et.al."Design and Analysis of a Space Frame Tubular Chassis for a Formula Student car" International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5 Issue 9, September 2016.

[7] Dr. Kirpal Singh, "AUTOMOBILE ENGINEERING" VOL. 2 by Standard publication, Delhi 13th edition 2014.

[8] Bhande Akshay S, et.al. "Detailed Design Calculation & Analysis of Student Formula 3 Race Car". International Journal of Science and Research, Vol. 7 Issue 6, June 2018.

[9] Tanawat Limwathanagura, et.al. "The Frame Analysis and Testing for Student Formula". International Scholarly and Scientific Research & Innovation. Vol. 6 Issue 5, June 2012.

[10] Hashfi Hazimi, et.al. "Vertical Bending Strength and Torsional Rigidity Analysis of Formula Student Car Chassis".3rd International Conference on Industrial, Mechanical, Electrical, and Chemical Engineering. April 2018.

[11] Prajwal Kumar M, et.al. "Design and Analysis of A Tubular Space Frame Chassis of A High Performance Race Car", International Journal of Engineering Research & Technology, Vol. 3, Issue 2, 2014.

[12] Das A, et.al,"Design of Student Formula Race Car Chassis". International Journal of Science and Research, Vol. 4 Issue 4, 2015.

[13] Chaudhari, K., et.al. "Design and development of roll cage for an all-terrain vehicle". International Journal on Theoretical and Applied Research in Mechanical Engineering, Vol. 2(4), 2015.

[14] Abdullah M A. "Development of formula varsity race car chassis". 2nd International Conference on Mechanical Engineering Research, 2013.

[15] Subramanyam B,et.al. "Analysis of Formula Student Race Car", International Journal of Engineering Research & Technology, Vol. 5, Issue 10, October 2016.