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DESIGN AND IMPACT ANALYSIS OF A ROLLCAGE FOR FORMULA HYBRID VEHICLE

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Abstract:

The Objective of this document is to highlight the final design report of Fusion with minimum deformation made by "Team Fusion" to compete in Asia's Biggest Hybrid vehicle Challenge 2018.The primary objective is to design a safe and functional vehicle based on a rigid and torsion-free frame, well mounted power train and to understand the finer aspects of vehicle design with the ulterior motive of fabricating prototype vehicle that could be manufactured for consumer sale. The secondary objective is to enhance driver's comfort and safety, and to increase the performance and manoeuvrability of the vehicle. To achieve our goal we have done the following things to make a perfect chassis frame according to our rule book and side by side optimizing our chassis design with the better and lighter material and stronger strength.

Keywords **—Design Material, chassis, Various Aspects of Chassis Analysis, Impact analysis,**

I. INTRODUCTION

The design and impact analysis of Fusion is done to achieve optimum results. And the primary focus is to form a chassis design that should satisfy our rule book and hence should resist the impact force on the chassis by analysis done on CAD software – soildworks. By using solidworks we have formed our design and optimize it in terms of strength and weight of the chassis. Along with it we have done research on the material which is best suited for our chassis design. The design majorly focuses on the safety serviceability, strength ruggedness, standardisation, cost, ergonomics and aesthetics.

DESIGN MATERIAL

Material selection is as important as modelling. Material must provide enough strength to the chassis to withstand the loads acting on it. Material with high density can increase the weight of the chassis and material with low density may result in breakdown in the middle of racing environment. While selecting the material, its availability in the market and the cost of the material is must be considered. Light weight and stiffness are the most important properties of the chassis and the stiffness of a complex chassis will be effect by the stiffness of the material from which it built. It was decided that the frame would be constructed from steel due to its availability and relatively low cost There are many different grades of steel available such as AISI 4130, AISI 1018, AISI 1020, AISI 4027,e.t.c..

The material AISI-4130 is used in the frame design because of its good weld ability, relatively strong as well as good manufacturability. A good strength material is important in a chassis because a chassis needs to absorb as much energy as possible to prevent the frame material from fracturing at the time of high impact. AISI-4130 has chosen for the chassis because it has structural properties that provide a low weight to strength ratio and also it satisfies the limitations mentioned in the rulebook.
Many of the teams around the world use 4130 grade steel (which contains Chromium and Molybdenum alloying elements) due to its higher yield strength. In the first part of the design phase when the chassis material was chosen, the team had a limited budget which resulted in the decision to use AISI4130. Lightweight and stiffness are the most important properties of a chassis and the stiffness of the completed chassis will be affected by the stiffness of the material from which it is built. Material

stiffness is known as Young's Modulus and the controlling mechanism for stiffness in a material is the inter-molecular forces. So stiffness or Young's Modulus is a material constant which cannot be significantly changed by any mechanical or chemical processes.

Comparison between AISI 1018 & AISI 4130

Properties	AISI 1018	AISI 4130
Yield Strength (MPa)	360	480
Young's Modulus (GPa)	210	210
Ultimate Strength (MPa)	420	590
Density (g/cc)	7.8	7.8
Elongation at break (%)	19	19
Thermal Conductivity: Ambient (W-m/K)	50	42
Thermal Expansion: 20C to 100C (µm/m-K)	11	12
Specific Heat Capacity Conventional (J/kg-K)	370	370
Strength to weight ratio at Yield (kN-m/kg)	38	100
Brinell Hardness	120	200

Table 1 Comparison between AISI 1018 & AISI 4130

Chassis

Chassis structures:-

In the world of motor sport, the most common types of chassis structure implemented are Monocoque chassis and space-frame chassis. Both types of chassis are discussed

1. Monocoque Chassis:-

Majority of the cars produced throughout the world are made of steel monocoque chassis. This structure is one-piece which defines the overall shape of the car. While other types of chassis provide only the stress members and need to build the body around them, the monocoque chassis is already incorporated with the body in a single piece.

The chassis is made by welding several pieces together to make a "one-piece" structure

1). Their major advantage is the benefit of crash protection. This is owed to the use of lots of metal which makes it easy for crumple zones to be built into the structure. Another advantage is the relatively high surface area to weight ratio of the body panels, but the numerous enclosed sections lead to high rates of corrosion.

2. Space-frame Chassis

Although the most popular type of chassis design in Formula one race cars is monocoque, however tubular space frame are also used especially in Formula student race cars. These frames comprise of series of tubes that are joined

Chassis and Impact Attenuator design for Formula Student Race car together to form a structure which connects all the important components together. The tubular members are "triangulated" to allow them to sustain loads in tension and compression only and do not deform due to bending or torsion to any high degree.

Various Aspects of Chassis Analysis:

The main aspect considered while designing our chassis are

1 Driver constraints (95 percentile), Safety of driver.

2 Rule book compliances

3 Vehicle dynamics

4 lightweight and high strength, reliability, easily manufacturability and Availability of material.

And according to all points above we have designed various types of chassis and three of them are shown here with the final one with all loads and force acting on the chassis.

First Design

First Design was Full filling all the required rule that are in the rule book and analysis of the forces on it is done which results in the stress and deformation scale with the help of software Solid works 2016.But due to the heavy weight in the chassis design and further modification we redesign the chassis and further modification for the proper modification of the design to get the optimum chassis design for our vehicle.

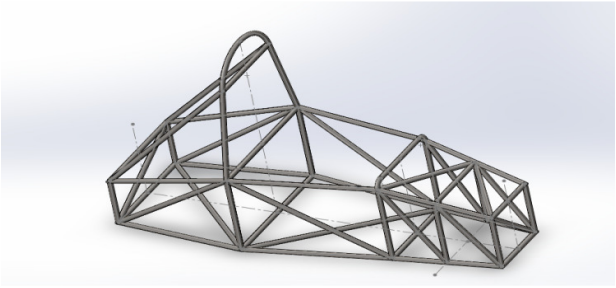


Fig.1 First design

First design for the event was formed was having some major property which are

Material used in AISI Steel 4130 Normalized at 870 °C
With pipe diameter 1 inches and internal thickness of 2.5mm
Density = 0.1286 kilograms per cubic inch
Mass = 58.8162 kilograms
Volume = 457.2208 cubic inches
Surface area = 7323.7257 square inches
Center of mass: (inches)
X = -0.0875
Y = 11.8838
Z = -40.5205

After making several design we have made some changes and only two more is discussed here after the formation of first design.

Second Design:-
The design is then modified to this kind of structure to get better then what it was previously done with the change in the front hoop Main hoop bracing the front part of the chassis and thus making it much more lighter and can bear force with larger value of the deformation scale and thus modifying our design.
Second design for the event was formed was having some major property which are

The material is now annealed at 830 C.
Material used in AISI 4130 Steel Annealed at 830 °C
Density = 0.13 kilograms per cubic inch
Mass = 51.00 kilograms
Volume = 396.49 cubic inches
Surface area = 6796.48 square inches

Center of mass: (inches)
X = 0.00
Y = 8.98
Z = 40.97

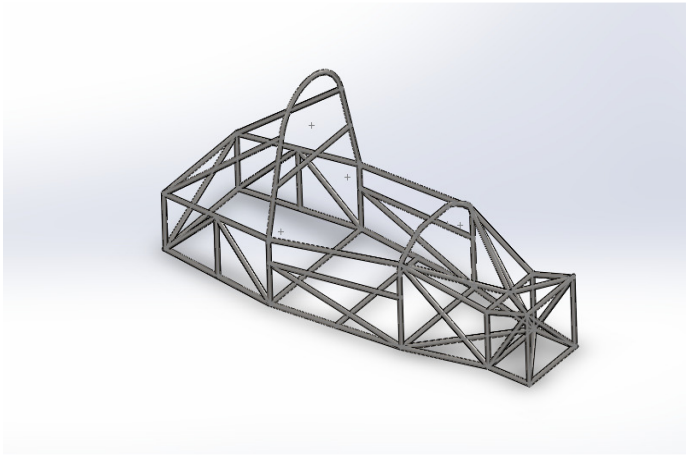
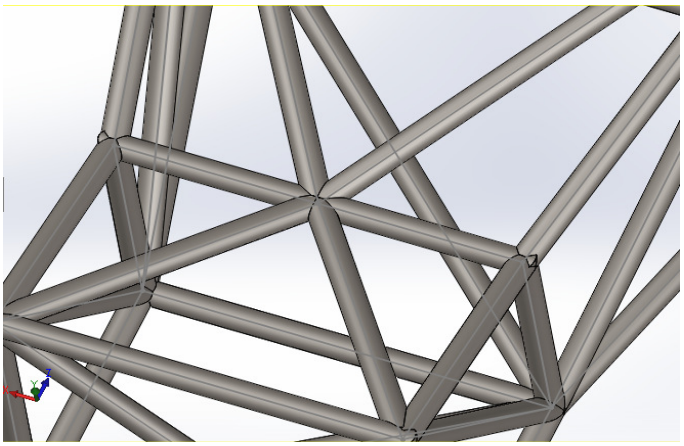


Fig.2 Second design



There are 4 weld joint at a single point which should be avoided to maintain the strength of the structure.

Third Design:-
Final Chassis Design for the Fusion
The new design is light in weight and can bear much more stress then previous one with modified arrangement of the pipe in proper place. The problem with this chassis is only at the front of the chassis where the meet point of 5 pipe at same point

so to remove this to get proper welding at the joint the new design is finalized to get the below problem sort.

Final design for the event was formed was having some major property which are
Density = 0.13 kilograms per cubic inch
Mass = 49.47 kilograms
Volume = 384.53 cubic inches
Surface area = 6583.90 square inches
Center of mass: (inches)
X = -0.06
Y = 9.30
Z = 42.55

Prototype:-

After that analysis and fulfilling the design consideration the prototype of chassis is must and so.Before going to design the whole chassis we must make a prototype from the PVC pipe to get a demo of how it will look if we are going to make the same model that is in the software and thus properly defining all the dimension correctly and making the groves properly in the pipes.

Real frame formed after prototype:-

Impact analysis:-

Front Impact-

For the front impact the force assumed is 4 times G, for that process
Total Weight of the vehicle = 300 kg
G = mxg
G = 300*10
G= 3000N
Front Impact 4G =4 x 3000 =12000
The force is applied on 4 nodes
So for each Node = 12000/4 = 3000 N
Result Factor of safety =1.66

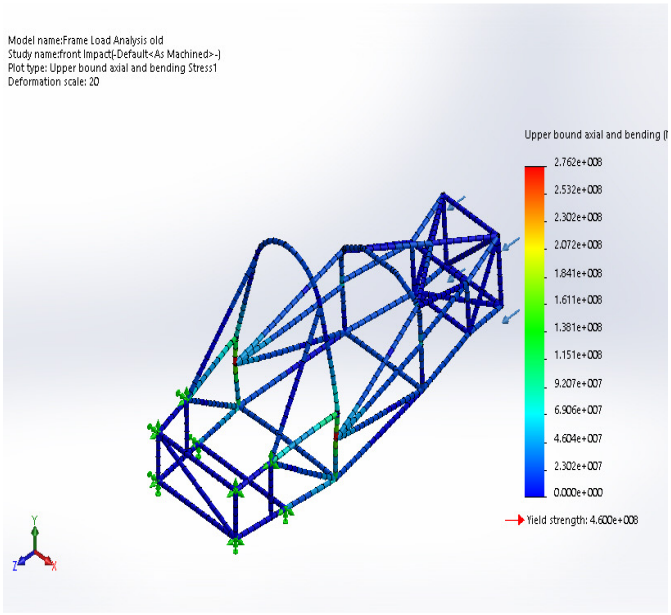


Fig. 5Frame Load Analysis-front Impact-Stress

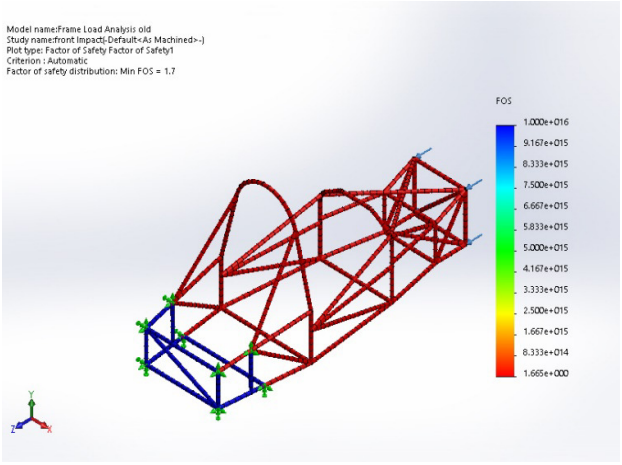


Fig. Frame Load Analysis-front Impact-Factor of Safety

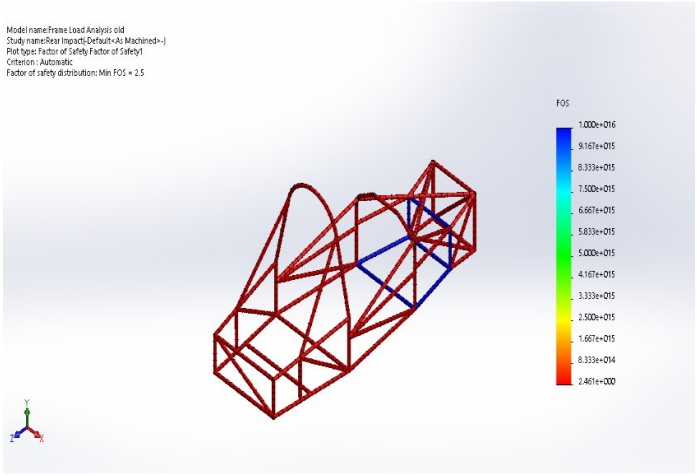


Fig. Frame Load Analysis Rear Impact-Factor of Safety

Rear Impact:

For the Rear impact the force assumed is 4 times G
For that process
Total Weight of the vehicle 300 kg
G = mxg
G = 300*10
3000N
Front Impact 4G =4 x 3000 =12000
The force is applied on 4 nodes
So for each Node = 12000/4 = 3000 N
Result Factor of safety = 2.4

Side Impact

For the Side impact the force assumed is 3 times G
For that process
Total Weight of the vehicle 300 kg
G = mxg
G = 300*10
3000N
Front Impact 3G =3 x 3000 =9000
The force is applied on 4 nodes
So for each Node = 9000/4 = 2250 N
Result Factor of safety = 2.3

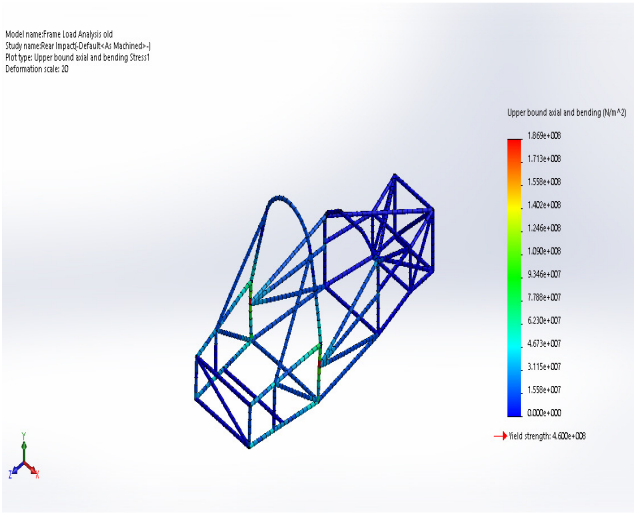


Fig. Frame Load Analysis-Rear Impact-Stress

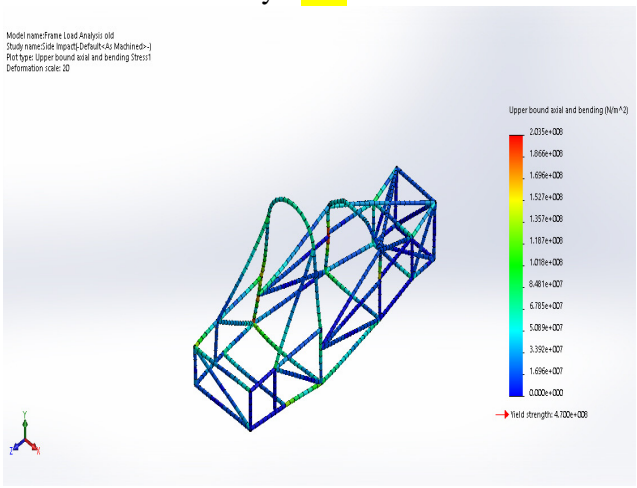


Fig. Frame Load Analysis-Side Impact

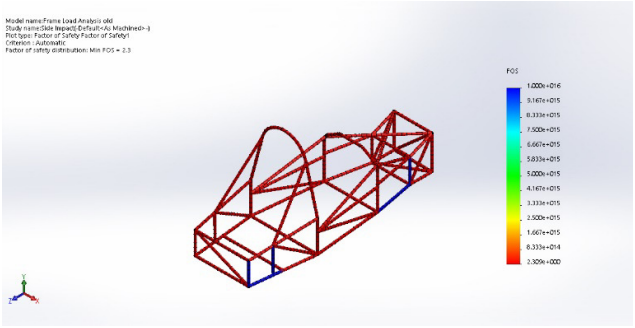


Fig. Frame Load Analysis-Side Impact-Factor of Safety

Rollover

For the Rollover impact the force assumed is 3 times G For that process

Total Weight of the vehicle 300 kg

G = mxg

G = 300*10

3000N

Front Impact 3G =3 x 3000 =9000

The force is applied on 4 nodes

So for each Node = 9000/4 = 2250 N

Result Factor of safety = 2.4

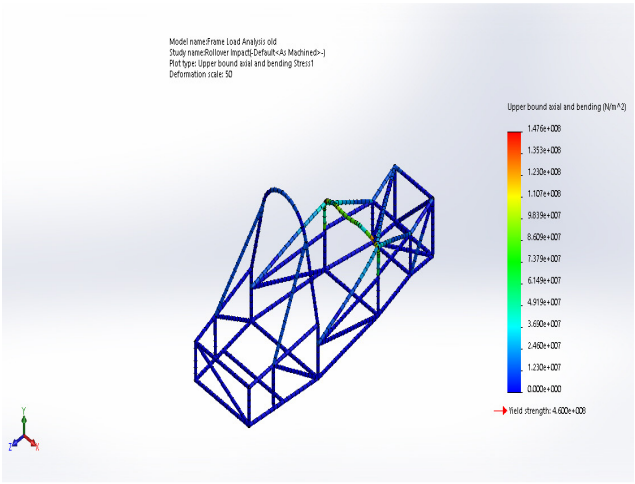


Fig. Frame Load Analysis Rollover Impact-Stress

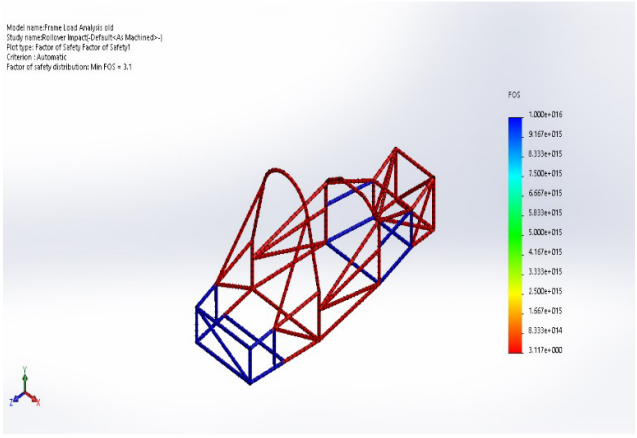


Fig. Frame Load Analysis Rollover Impact-Factor of Safety

II. CONCLUSIONS

The team's goal is to build the lightest possible frame to maximize performance, without any hindrances to the strength of the chassis. The analysis is done by taking various factor. The result shows that all the forces applied on it is in safe condition and there will be no any break in the pipes and the joints. The event in which we have to submit our car is done. The event held at Galgotias University from 17 Feb 2018 to 22 Feb 2018. We have cleared our Technical Inspection round as no any sort of problem was there at the T.I round. Fusion is not only meant for the competition but our team has dedicated this vehicle as a tribute to our Indian Army Which was well appreciated by Army and our college.

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