Static Structural Analysis of Roll Cage for Self Propelled Onion Harvester

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Abstract – *Today harvesting machine have an important role in agricultural mechanization application. The harvesting of onion crop is rigorous, requires huge amount of man power and time. For that purpose we have developed self-propelled onion harvester which will have good performance in term of productivity, fuel economy, less damage to crop and operator comfort. The roll cage forms a structural base & 3-D shell around the driver. The objective of the study is to analyze and optimize the roll cage designed under a set of particular rules given by Society of Automotive Engineers (SAE). Also obtain optimum factor of safety which ensures that the roll cage of machine will be safe in all conditions.*

***Key Words*: Roll cage, Operator comfort, Solid works, Static structural, ANSYS**

1. INTRODUCTION

The roll cage is a structure support various component & body of the vehicle in addition to loads it is supposed to carry. The design factor contains safety, easy manufacturing, durability & maintenance of the frame and a compact, lightweight & ergonomic design. The roll cage is designed under the guidelines of SAE-TIFAN rulebook. The principle function of roll cage is to safely carry the maximum load for all designed operating conditions. All system of self-propelled harvester machine are mounted on the roll cage. The roll cage receives the reaction forces of the wheels during acceleration and braking and also absorbs aerodynamic wind forces. So the roll cage should be engineered and built to maximize payload capability and to provide versatility, durability as well as adequate performance.

There are several options for manufacturing the chassis/roll cage; space frame, ladder frame, sub-type frame, perimeter frame, unit body construction etc. we opted to manufacture our roll cage in form of space frame which can be easily manufactured.

2. DESIGN METHODOLOGY

Design of any component is consists of three major principles: 1.optimization 2.safety 3.comfort. The primary objective of the roll cage is to provide a 3-dimensional protected space around the driver that will keep the driver safe. Its secondary objectives are to provide reliable mounting locations for components, be appealing, low in cost, and low in weight. These objectives were met by choosing a frame material that has good strength and also weighs less giving us an advantage in weight reduction. A low cost frame was provided through material selection. Solidwork 2017 was used to model a frame that is aesthetically appealing and meets all requirements.

2.1Dimensions

The roll cage must ensure enough clearances from members for free movement of the driver. In order to reduce the weight two members with different cross sections are used to construct the roll cage. The diameter of the member is 25.4mm & wall thickness is 3mm.

Table -1: Overall Machine Specifications

Sr. No	Parameter	Specification
1	Machine Type	4 Wheel
2	erall dimensions (L x B x H)	2550 x 1600 x 1776 mm

3	Static Ground Clearance	300 mm
4	Machine weight	570 kg
5	Wheel Base	1550 mm
6	Wheel track width	1450 mm
7	CG location from machine mid plane & wheel Centre	367mm
8	Max. Speed	15 km/hr
9	Working Width	900 mm
10	Working Depth	100 mm

3. ELECTION OF MATERIAL

In roll cage design selection of material is one of the most important factor considered because it has great impact on safety, reliability & performance. It must sustain any forces acting on roll cage without deformation. So the roll cage must have certain stiffness to absorb vibrations and high temperature produced by the engine. As per the SAE-TIFAN rule book the material should contain at least 0.18% carbon content. So our initial step was carry out market survey to get the material having required properties according to rulebook with affordable cost. Based on market survey we chosen material namely-AISI 1018. It is also known as low carbon steel. It has capability to withstand stresses without deformation. For chassis structure, we used 2 types of material sections.

i. Pipe Section: - Outer Dia. = 25mm, Thickness = 3mm
ii. L Channel: - Length = 50 mm, Thickness = 5mm

Table -2: Properties of AISI 1018

Density (kg/m^3)	7800
Young's Modulus (MPa)	2.1×10^5
Poisson's Ratio	0.29
Yield Strength (MPa)	370
Ultimate Strength (MPa)	440

Table-3: Chemical Composition AISI-1018

Carbon	0.14-0.20%
Iron	98.91-99.26%
Manganese	0.6-0.9%
Phosphorous	≤0.040%
Sulphur	≤0.050%

4. ROLLCAGE DESIGN

Geometry modelling of various component of roll cage was design solidwork 2017 complying rules mentioned in the SAE-TIFAN 2019 rulebook. The FEA simulation where carried out to optimize the sizing of tubes ensuring it withstands the loads. Several integration were carried out to reduce the weight.

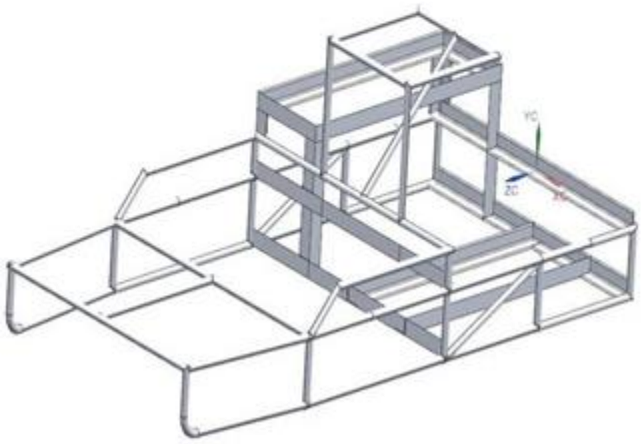

Fig -a: SolidWorks model of roll cage

5. STATIC STRUCTURAL ANALYSIS

5.1 Mesh

Meshing of roll cage was carried out. In finite element analysis, part geometry is divided into small volumes to solve it easily. Each small volume is called an element. Each element has a set of points called nodal points or nodes. Nodes are usually located at the endpoints of elements. The Table below gives the details of nodes and elements of the model.

Table-4: Statistics

Entity	Size
Node	105957
Element	29149

5.2 Static Analysis

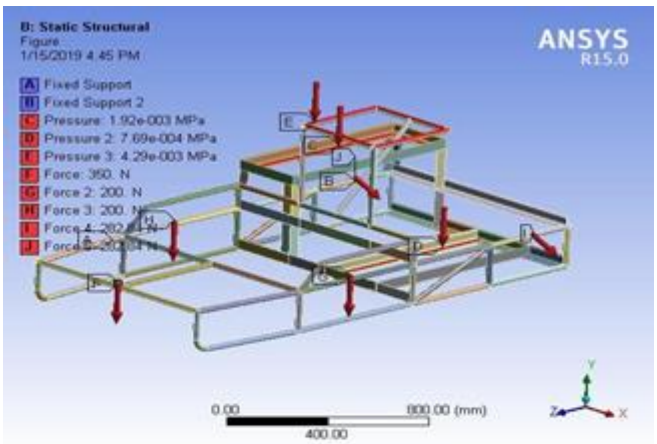

Fig -5.1(a): Applied Force

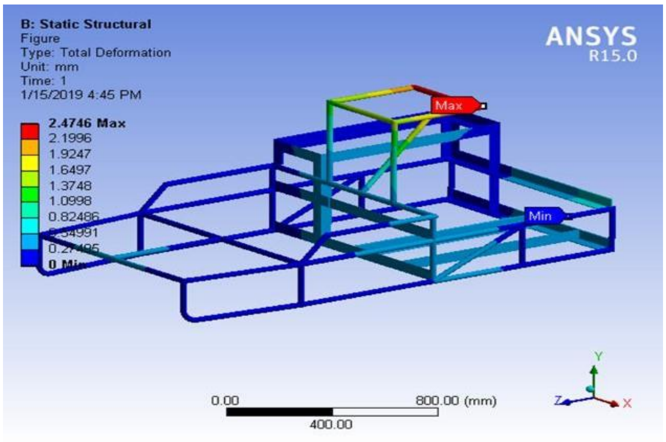

Fig -5.2(b): Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]
1.	0	2.4746

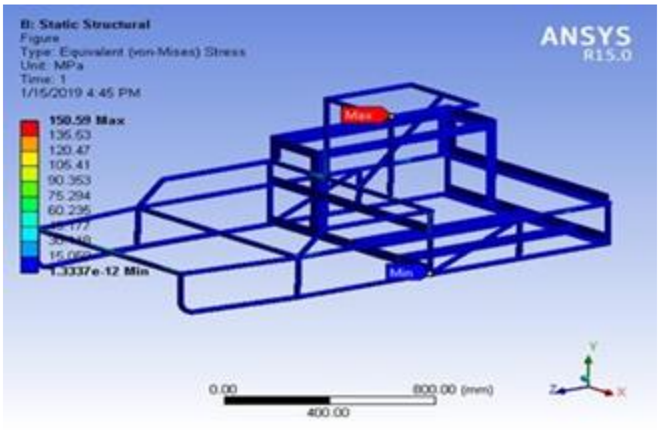

Fig -5.3(c): Von-Mises Stress

Time[s]	Minimum [MPa]	Maximum [MPa]
1.	1.3337e-012	150.59

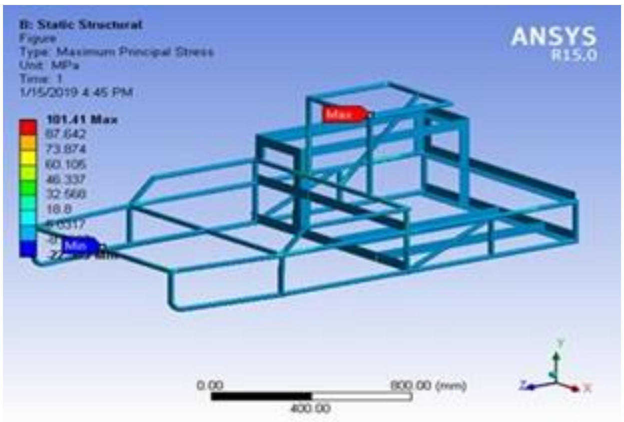

Fig -5.4(d): Maximum Principal Stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	-22.303	101.41

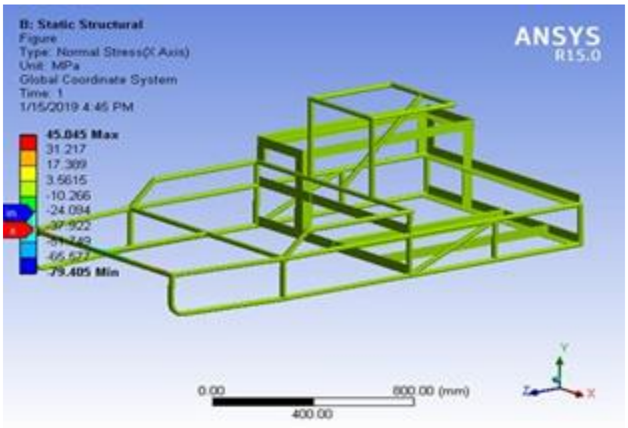

Fig -5.5(e): Normal Stress (X-Axis)

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	-79.405	45.045

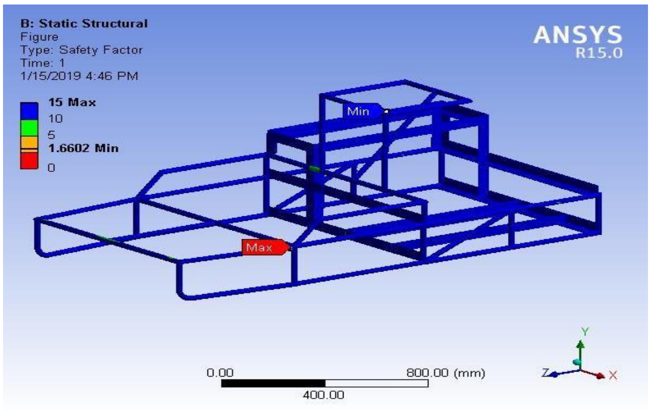

Fig -5.6(f): Factor of Safety

6. CONCLUSION

We have implemented a technique of roll cage design for SAE-TIFAN competitions from initial stage to final stage. We optimized the models with this project and the same on ANSYS in compliance with stringent rules of the event. We also took realistic approach for material selection. As well as we have studied all the factors which are necessary to keep in mind while designing a roll cage. We have done a Finite Elemental Analysis of the roll cage and hence we conclude that the roll cage has required value of Factor of safety and it is safe for a driver.

REFERENCES

[1] SAE-TIFAN Rulebook 2019
[2] Deepak Raina, "Design & Development of Roll Cage of All-Terrain Vehicle", IJTRE, ISSN: 2347-4718, Vol.:2, Issue: 7, March 2015.
[3] Automobile Mechanics, Dr.N.K.Giri, Khanna Publication 8th edition 2015.
[4] Santanu Chakraborty, "Static Analysis of Roll Cage", IJETAE, ISSN: 2250-2459, Vol. 4, Issue 2, February 2014.
[5] Tushar Patangray, "Static Analysis of Roll Cage of All-Terrain Vehicle", IRJET, ISSN: 2395-0056, Vol.: 5, Issue: 8, Aug 2018
[6] Strength of Machine Element, Prof.R.K.Rajput S.Chand Publication edition 2008.

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