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DESIGN, ANALYSIS AND MATHEMATICAL MODELLING OF EFFICYCLE

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Abstract - *In the present day's energy markets are conquered by a significant raise in energy demand due to the strong economic growth in the developing countries especially in China and India. At the same instant the developing countries as well as developed countries are also suffering from the problems related to lack of fossil fuels and the pollution generated from the use of the fossil fuels. Efficycle is generally propelled by human energy which is ergonomically and aerodynamically stable. Present study has been carried out with regard to the static analysis of a chassis under certain variable factors, like for Front, Rear and Side impacts. The proposed model is powered with electrical motor, in addition to human power. Both the options may work independently, we did start our vehicle design with some hand sketches proceeded by designing our vehicle with every specification, keeping in mind the rulebook issued for EFFICYCLE 2017. For our designing, we have used CREO 3.0 software and for analysis purpose we have used ANSYS 16.0*

Key Words: Efficycle, Static Analysis, Human power, Electric power, Pollution.

1. INTRODUCTION

The pollution produces by the vehicles is a big problem. And another huge problem related to the transportation is decrement in the reserve fossil fuels. Here we have need of some alternative system or any kind of technology which is not depends on the fossil fuels and also not produces air pollutants. Combined human and electric powered vehicle could be a good example of such kind of alternative solution and we can use it in future for small distance transportation. Tricycle rickshaw is a very cheap means of short distance transportation both in city and in rural areas.

1.1 Frame Material Options

The frame material steel or steel alloys are selected based on availability, strength, machinability, and light weight as well as economical. So, we have selected "CHRO-MOLY AISI 4130" & "STEEL AISI 1018" as an option for frame material.

Material-1 (AISI1018)

Cross-Section Type; 25.4mm x 21.4mm x 2mm

Material-2 (AISI4130)

Cross-Section Type; 25.4mm x 21.4mm x 2mm

Table -1: Materials Properties

S. No.	Mechanical Properties	Material 1 (AISI1018)	Material 2 (AISI4130)
1.	Yield strength	365MPa	460MPa
2.	Ultimate strength	440MPa	560MPa
3.	Elongation	15%	11-13%
4.	Carbon %	0.20	0.28
5.	Density	7.87gm/cc	7.85gm/cc
6.	Machinability	Good	Average
7.	Welding method	MIG	TIG

1.2 Comparison of Bending Strength and Bending Stiffness

S. No.	Parameter	Material 1 (AISI 1018)	Material 2 (AISI 4130)	Reference Material (25.4mmx 21.4mm x 2mm)
1.	Bending Strength (N-m)	291.33	367.16	291.33
2.	Bending Stiffness (N/m2)	2078.02	2078.02	2078.02

2. CAE ANALYSIS OF VEHICLE FRAME

The Finite Element Analysis (FEA) of the vehicle was done using ANSYS 16.0. The stress analysis was done under worst case scenarios and maximum forces were applied in the analysis. Adequate factor of safety was ensured for all the components under these worst case conditions. The analysis includes front impact, side impact, and side rollover

2.1 Frontal Impact Analysis

Assumption& Considerations:

For the analysis of both AISI 1018 and AISI 4130 the weight of the vehicle is kept 330 Kg with driver. Other than this some assumptions which are kept in considerations are as follows

Conditions	Front Impact
Velocity (Km/hr)	30
Time of Impact (sec)	0.2
Force (N)	13,750

Analysis Results:

1 Material-1 (AISI 1018, 25.4mm x 21.4mm x 2mm)

RESULT	FRONT IMPACT
Max. Equivalent Stress (MPa)	323.84
Factor of Safety	1.12
Max. deformation (mm)	2.109

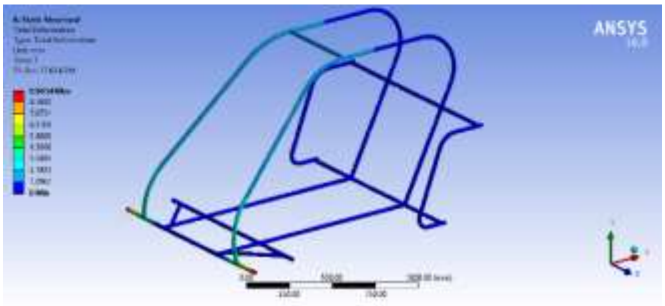

Fig -1: Maximum Deformation

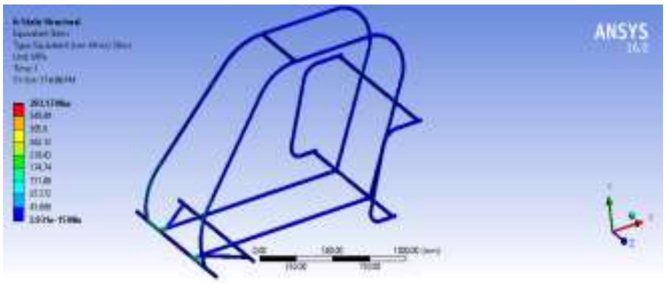

Fig -2: Maximum Equivalent Stress

2 Material-2 (AISI 4130, 25.4mm x 21.4mm x 2mm)

RESULT	FRONT IMPACT
Max. Equivalent Stress (MPa)	323.84
Factor of Safety	1.42
Max. deformation (mm)	1.947

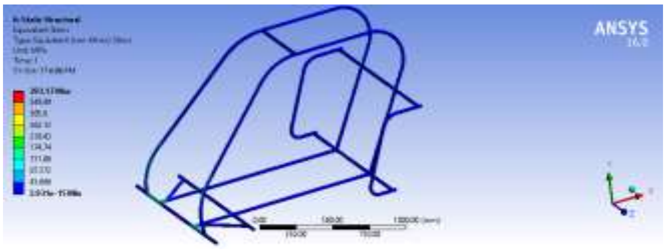

Fig -3: Maximum Equivalent Stress

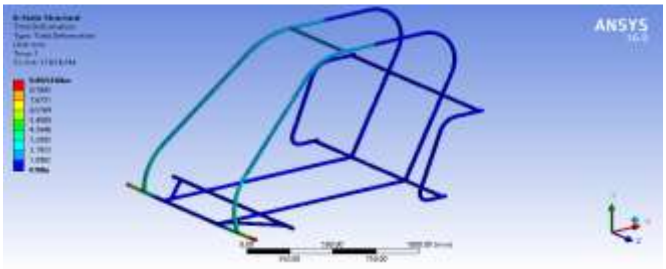

Fig -4: Maximum Deformation

Optimization:

Fig -5: Earlier Design

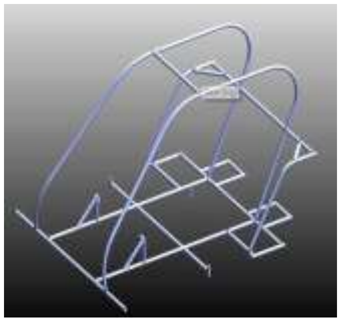

Fig -6: Optimized Design

2.2 Side Impact Analysis

1 Material-1 (AISI 1018, 25.4mm x 21.4mm x 2mm)

RESULT	SIDE IMPACT
Max. Equivalent Stress (MPa)	393.07
Factor of Safety	0.92
Max.Deformation (mm)	3.866

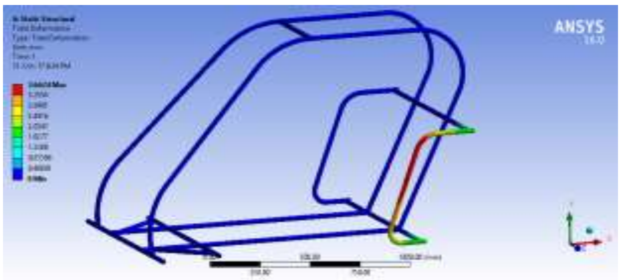

Fig -7: Maximum Deformation

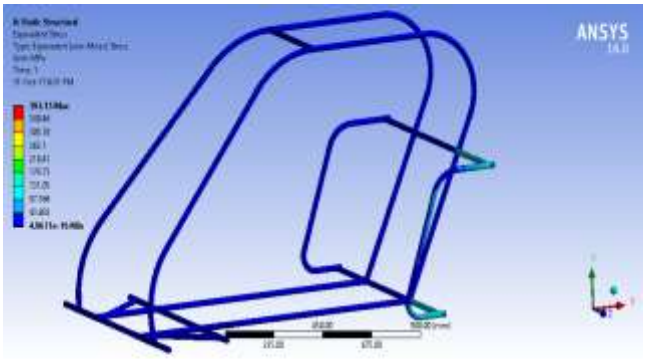

Fig -8: Maximum Equivalent Stress

2 Material-2 (AISI 4130, 25.4mm x 21.4mm x 2mm)

RESULT	SIDE IMPACT
Max. Equivalent Stress (MPa)	393.07
Factor of Safety	1.17
Max. Deformation (mm)	3.620

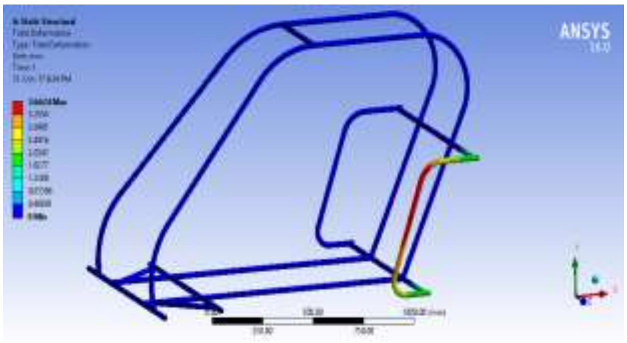

Fig -9: Maximum Deformation

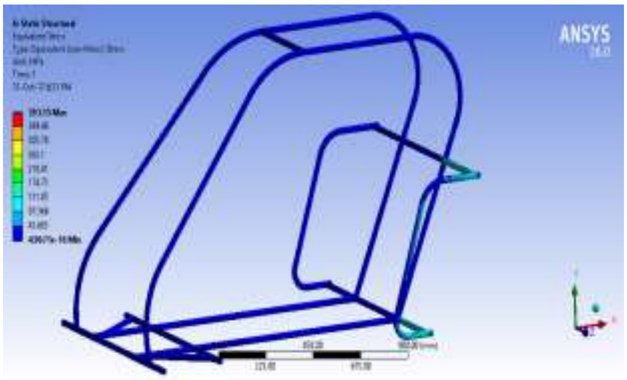

Fig -10: Maximum Equivalent Stress

Optimization:

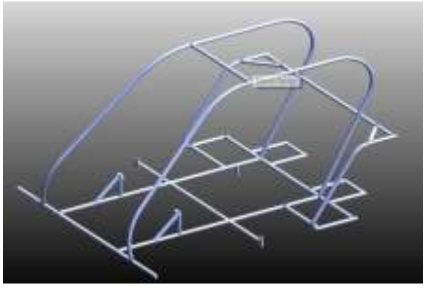

Fig -11: Optimized Design

2.3 Rollover Analysis

1 MATERIAL-1 (AISI 1018, 25.4mm x 21.4mm x 2mm)

RESULT	ROLLOVER
Max. Equivalent Stress (MPa)	275.97
Factor of Safety	1.32
Max. Deformation (mm)	5.013

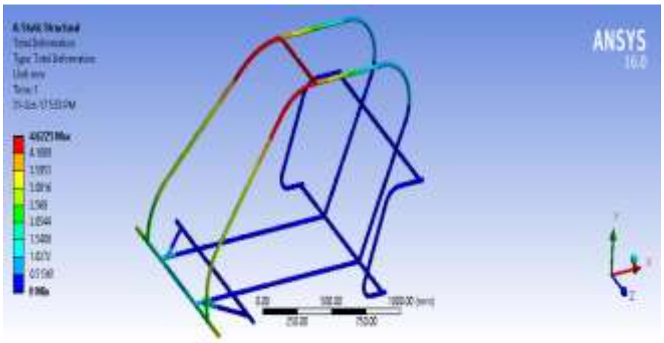

Fig -12: Maximum Deformation

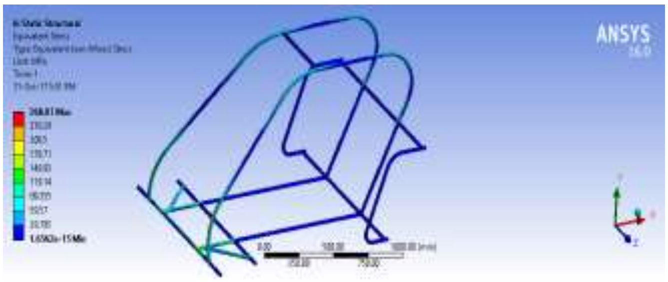

Fig -13: Maximum Equivalent Stress

2 MATERIAL-2 (AISI 4130, 25.4mm x 21.4mm x 2mm)

RESULT	ROLLOVER
Max. Equivalent Stress (MPa)	275.97
Factor of Safety	1.66
Max. Deformation (mm)	4.800

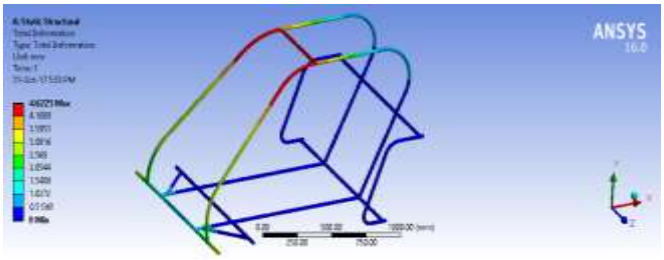

Fig -14: Maximum Deformation

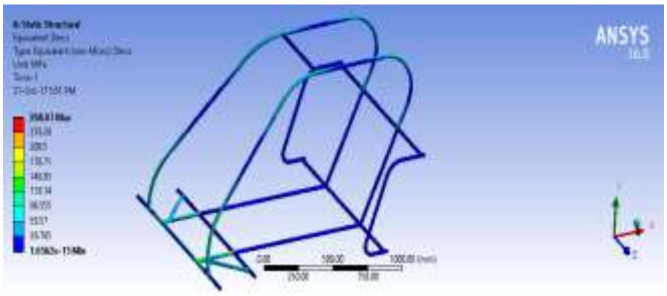

Fig -15: Maximum Equivalent Stress

Optimizations:

We have included overhead members to protect driver in case of rollover without compromising with driver ergonomics.

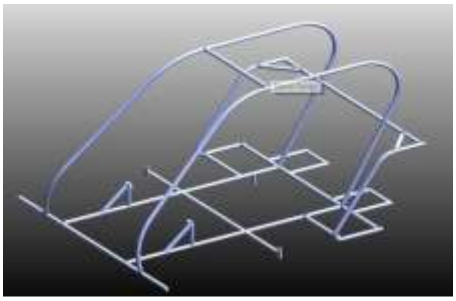

Fig -16: Optimized Design

3. CONCLUSIONS

From our options, we have selected CHRO-MOLY (AISI 4130) as our frame material. As from the comparison table show above it is very clear that factor of safety is more in AISI 4130 compare to AISI 1018. Other than this strength by weight ratio is also more of AISI 4130 than AISI 1018. Maximum deformation is less in all the impacts that are analyzed on the software. Even after optimizing our vehicle design, strength of AISI 1018 was less than AISI 4130. So, we have finalized CHRO- MOLY AISI 4130 as our final frame material.

S. No.	PARAMETERS	Type	MATERIAL 1 (AISI 1018)	MATERIAL 2 (AISI 4130)
1.	Max. Equivalent stress (MPa)	Front impact	323.84	323.84
		Side impact	393.07	393.07
		Rollover	275.97	275.97
2.	Max. deformation (mm)	Front impact	2.109	1.947
		Side impact	3.866	3.620
		Rollover	5.013	4.800
3.	Factor of safety	Front impact	1.12	1.42
		Side impact	0.92	1.17
		Rollover	1.32	1.66

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