Design of Solar Car Chassis

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ABSTRACT

The aim is to design, analyze and fabricate a roll cage for Electric Solar Vehicle. It deals with modeling of roll cage of SOLAR POWERED VEHICLE and analyzing it to give an optimum design. The main objective of this research work is to perform analysis (structural) on our frame considering the safety and ergonomics of driver during any collision or accident, to have a compact frame with less weight and with good aesthetics as well. The structure model is prepared in SOLIDWORKS 2018 software and analysis is also done in SOLIDWORKS.

KEYWORDS: Solar car, chassis, design, analysis


INTRODUCTION

The aim was to design a vehicle that can contribute towards environmental stability and at the same time is easy to manufacture, stable and also cost effective. The design methodology involved recognition of customer’s need and market survey that led to design of a vehicle with adequate safety and good ergonomics.

Design and Calculations:
➢ Frame design
➢ Material selection and Comparison
➢ Comparison of different material for Roll Cage
   1. Formula Used
   2. Frame Dimension
   3. Roll cage and Frame Analysis (FEA)

FORMULA USED:

\[ \text{BENDING STRENGTH} = \frac{\text{YIELD STRENGTH}}{\sqrt{2}} \times \text{MOMENT OF INERTIA} \]

\[ \text{BENDING STIFFNESS} = \frac{\text{Young's Modulus}}{\sqrt{2}} \times \text{MOMENT OF INERTIA} \]

\[ \text{MOMENT OF INERTIA} = 3.14(R_{1}^{4} - R_{0}^{4}) \]

1. Frame Dimension:
   Configuration tadpole design specs are as below:
   - Length*width = 2185mm*1474mm
   - Height = 1397mm
   - Wheelbase= 1524mm
   - Track width= 1320mm
   - Frame weight= 28kg

Table1: COMPARISON OF DIFFERENT MATERIALS FOR ROLL CAGE

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>AISI1020</th>
<th>AISI4130</th>
<th>AA6063 T6</th>
<th>AA6061 T6</th>
<th>AISI 1018</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIMENSIONS</td>
<td>0.03 inch</td>
<td>0.03 inch</td>
<td>0.03 inch</td>
<td>0.03 inch</td>
<td>0.03 inch</td>
</tr>
<tr>
<td>YIELD STRENGTH</td>
<td>351.5MPa</td>
<td>460MPa</td>
<td>251MPa</td>
<td>260MPa</td>
<td>370MPa</td>
</tr>
<tr>
<td>DENSITY</td>
<td>7900kg/m³</td>
<td>7850kg/m³</td>
<td>2700kg/m³</td>
<td>2700kg/m³</td>
<td>7870kg/m³</td>
</tr>
<tr>
<td>TENSILE STRESS</td>
<td>420.1MPa</td>
<td>731MPa</td>
<td>240MPa</td>
<td>300MPa</td>
<td>440MPa</td>
</tr>
<tr>
<td>BENDING STIFFNESS</td>
<td>561.1MN-m</td>
<td>734.1MN-m</td>
<td>1425.25MN-m</td>
<td>1455.25MN-m</td>
<td>109.76MN-m</td>
</tr>
<tr>
<td>BENDING STRESS</td>
<td>4155.35N/m²</td>
<td>4155.35N/m²</td>
<td>8702.07N/m²</td>
<td>8702.07N/m²</td>
<td>4155.35N/m²</td>
</tr>
<tr>
<td>MOMENT OF INERTIA</td>
<td>2.027*10⁻⁴ m⁴</td>
<td>2.027*10⁻⁴ m⁴</td>
<td>1.263*10⁻⁴ m⁴</td>
<td>1.263*10⁻⁴ m⁴</td>
<td>2.027*10⁻⁴ m⁴</td>
</tr>
</tbody>
</table>
After analyzing and comparison we decide to go with the material AISI-4130. Because it has more strength than any other material.

2. Roll cage/Frame Analysis (FEA):
After finalizing the frame along with its material and cross section. It is very important to test the chassis under several conditions.

Following test are performed on the roll cage:
- Front Impact
- Rear Impact
- Side Impact test
- Torsional test
- Roll over test

<table>
<thead>
<tr>
<th>Material</th>
<th>PIPE SIZE</th>
<th>Weight(kg)</th>
<th>CALCULATED FOS (force in Newton)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outer Dia (in)</td>
<td>Inner Dia (in)</td>
<td>Front Impact</td>
</tr>
<tr>
<td>AISI 4130</td>
<td>1.25</td>
<td>1.25</td>
<td>28</td>
</tr>
<tr>
<td>AISI 4130</td>
<td>1.25</td>
<td>1.25</td>
<td>33.5</td>
</tr>
<tr>
<td>AISI 4130</td>
<td>1.5</td>
<td>1.25</td>
<td>37.46</td>
</tr>
<tr>
<td>AISI 1020</td>
<td>1.25</td>
<td>1.25</td>
<td>38.4</td>
</tr>
<tr>
<td>AISI 1020</td>
<td>1.25</td>
<td>1.5</td>
<td>31.55</td>
</tr>
<tr>
<td>Al 6063-T6</td>
<td>1.5</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>Al 6063-T6</td>
<td>2</td>
<td>3</td>
<td>34.38</td>
</tr>
<tr>
<td>Al 6061-T6</td>
<td>1.5</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Al 6061-T6</td>
<td>2</td>
<td>3</td>
<td>30.46</td>
</tr>
</tbody>
</table>

We decided to opt AISI 4130 pipe of dimension 1in*1.25mm cause it is providing us the best FOS with less weight

1. FRONT IMPACT TEST:-
**ASSUMPTIONS:** -
M = 250Kg
Vf = 13.88m/s VF = 0m/s Time= 0.2s
F= 7220/1.534 = 4750N

**NO. of Beams = 2**
Force per beam = 4750/2 = 2375
Momentum=Impact
250*13.88*F*0.2F = 17362N Number of nodes = 6
Force/node=2900N (approx)

Max. Stress = 189.9N/mm²
Max. Displacement = 3.937 mm
FOS = 2.4

2. REAR IMPACT TEST:
F=Rear=17362N
FOS=1.4

3. SIDE IMPACT TEST:-
Ffront=17362N
Fside=Ffront/2 = 8681N
**No of Nodes=4**
**Force/node=2171N**

![Stress analysis on front side.](image)
Max. Stress = 392.26 N/mm$^2$
Max. Displacement = 1.762 mm
FOS = 1.2

4. Torsional Analysis:
$F_{\text{front}} = 17362\text{N}$
$F_{\text{Torsion}} = F_{\text{front}}/4 = 4340.5$
$F_{\text{side}} = 4340.5/2 = 2170.25\text{N}$
No of nodes = 4
Force/node = 542.56 N

5. Roll over analysis:
$mgh = \frac{(mv^2)}{2}$
$V = (2gh)^{0.5} = (2 \times 9.8 \times 3)^{0.5}$
$W = \frac{mv^2}{2} = \frac{(240 \times 7.66^2)}{2} = 7220 \text{ J}$
Frictional Force = $\mu mxg$
$= 0.57 \times 250 \times 9.8$
$= 1396.56 \text{ N} = 1400 \text{ N}$
Analysis of Roll over (FOS = 3.3)

Fig 2: a,b,c represents stress analysis on side.

Fig 3: a,b,c represents the stress analysis of torsional test.

Fig 4: represents the stress analysis on roll over test.
6. **Roll cage Different views**

**A. FRONT VIEW**

![Roll cage Front View]

**B. SIDE VIEW**

![Roll cage Side View]

**C. TOP VIEW**

![Roll cage Top View]

7. **CONCLUSION**

After performing calculation and simulations on the roll cage we found that the AISI 4130 is selected for manufacturing of roll cage for solar vehicle of dimensions (outer diameter 1inch and inner diameter 1.25inch and thickness of linch) it has less weight and better factor of safety.

**REFERENCES**


[8] Shubham Kolhe, Vrushabh U. Joijode; ROLL CAGE DESIGN AND ANALYSIS FOR FORMULA STUDENT RACE CAR, INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES AND RESEARCH TECHNOLOGY.