DESIGN AND FABRICATION OF ELECTRIC - SOLAR VEHICLE

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ABSTRACT:- The aim of these research paper is to cover all the design aspects of the designing and analysis of the preliminary solar vehicle. Apart from this, it deals with components which are integrated into the vehicle. It uses BLDC motor which is having supply of 1.5KW from lead acid battery. It also includes rack and pinion steering mechanism, Hydraulic type breaking system and also double wishbone 'A' type suspension system.

KEYWORDS: Preliminary solar vehicle, BLDC motor, lead acid battery, rack and pinion, hydraulics, double wishbone, chassis design, Battery, Motor.

INTRODUCTION:

ESVC (Electric Solar Vehicle Championship) is an event organized by ISIE INDIA (Imperial Society of Innovative Engineers) for enhancing and implementing their practical knowledge by designing and fabricating Electric Solar Vehicles in order to compete with the students which are participating in the event. This paper mainly focuses on the difficulties faced by the students while performing calculations and designing of various parts of the Electric Solar Vehicle.

The purpose of this research paper is to design, calculate and analyze different parts of vehicle so that the vehicle is fabricated at minimum possible cost without compromising with the safety of the driver. We are using SOLIDWORKS 2016 for the designing of the chassis modeling of the vehicle and testing it against all types of failure, stresses and deformation. Based on design, calculation and analysis result can be change as per further modifications in dimensions.

CONTENT:

Material Selection Process:

The carbon content in the steel is very important to determine the hardness, strength, machining and welding characteristics. Material selection for chassis plays a vital role in building up of entire vehicle in providing reliability, safety and endurance. The steel which has carbon increases the hardness of the material. Aluminum alloy is expensive than steel, in that case steel is the most preferable material for fabricating the chassis.

The chassis material is considered depending upon the various factors such as maximum load capacity, absorption force capacity, strength, rigidity. The material selected for chassis building is AISI 1018. AISI 1018 is a mild/low carbon steel.

Composition of AISI 1018

Composition	AISI 1018
Iron	98.8 to 99.2%
Manganese (Mn)	0.6 to 0.9%
Carbon (C)	0.15 to 0.2%
Sulfur (S)	0 to 0.050%
Phosphorus (P)	0 to 0.040%

Properties Of AISI 1018

PROPERTIES	AISI 1018
Density	7.9g/cm3
Elastic (Young's, Tensile) Module	210GPa

Fig:1 Orthographic images of CAD model of Chassis

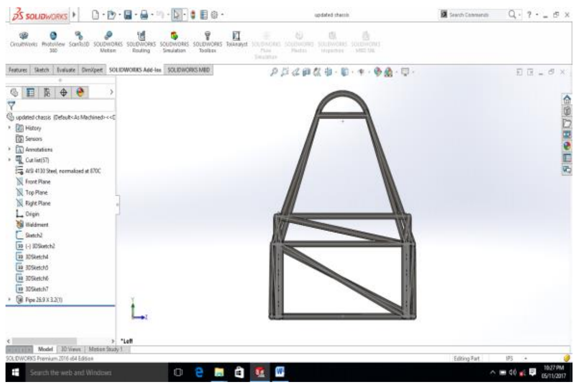


Fig 2. Front View

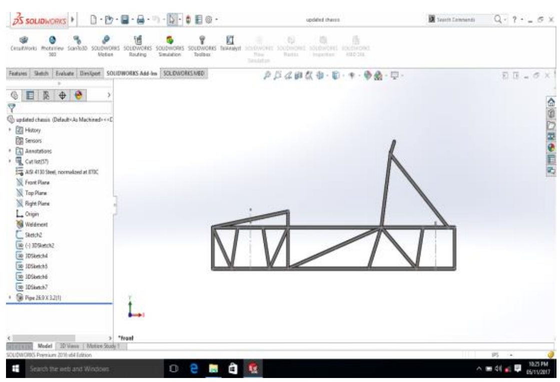


Fig3. Side View

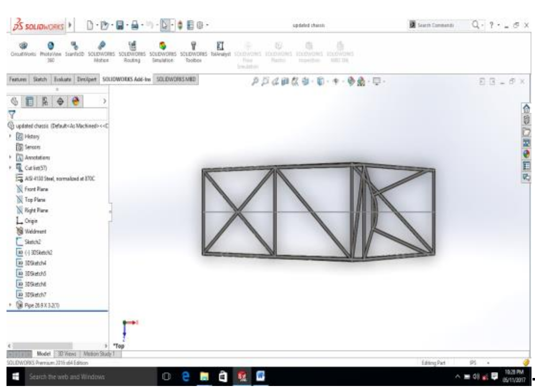


Fig 4. Top View

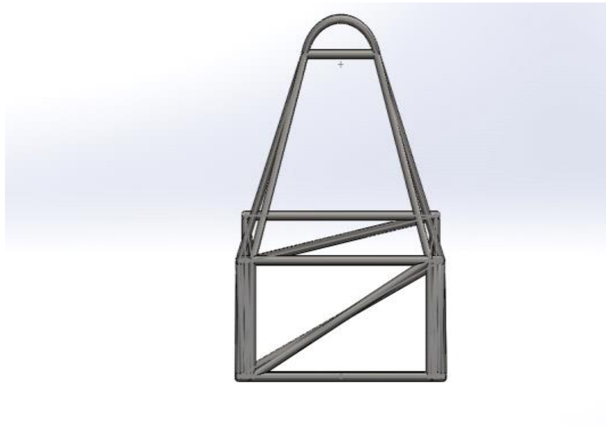


Fig 5. Rear View

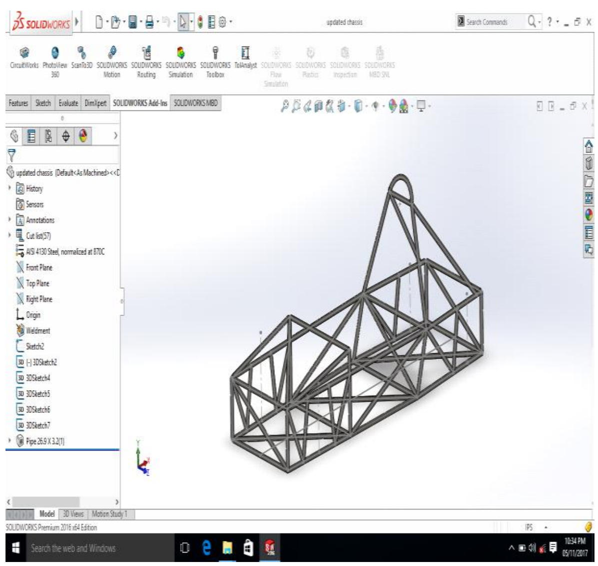


Fig 6. Isometric View

Reports showing CAE simulation on chassis, along with calculation :

Front impact displacement:

Front impact was calculated for an optimum speed of 40 kmph. The loads were applied only at front end of the chassis because application of forces at one end, while constraining the other, results in a more conservative approach of analysis. Time of impact considered is 0.13 seconds as per industrial standards.

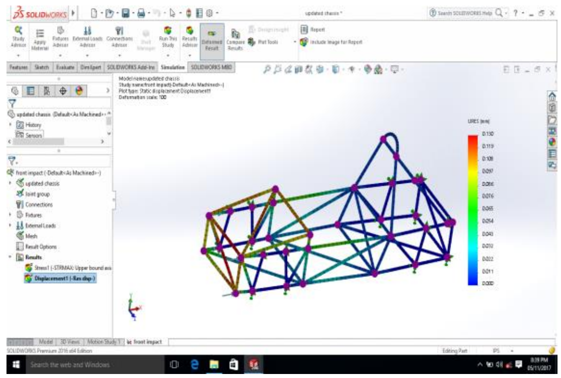
We know. According to Force work relation

Work done = Force * Displacement

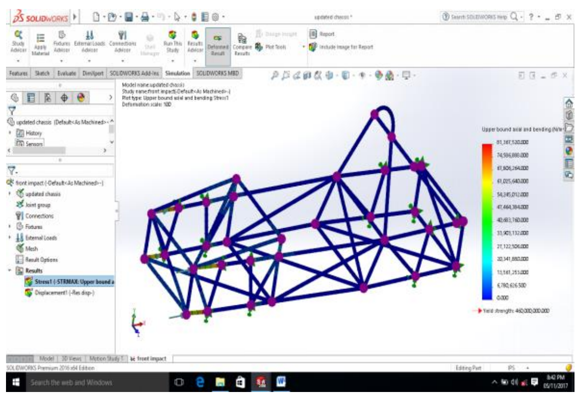
Force =9611.2N

Displacement =1.08m

Work done = 10.3KNm



Front impact stress:



Rear impact displacement:

Considering the worst case collision for rear impact, force is calculated as similar to front impact for speed of 40 kmph. Load was applied at rear end of the chassis while constraining front end and king pin mounting points. Time of impact considered is 0.13 seconds as per industrial standards.

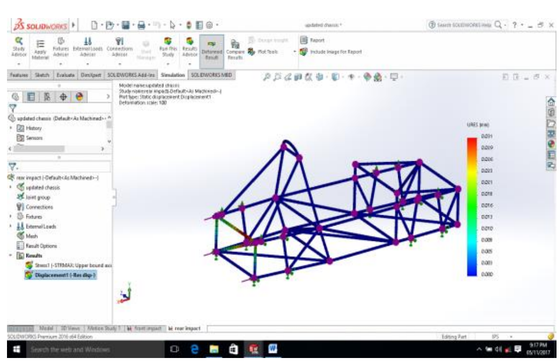
We know. According to Force work relation

Work done = Force * Displacement

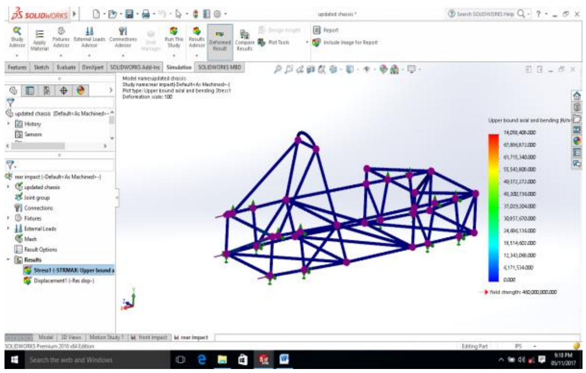
Force =4164 N

Displacement =2.499m

Work done = 10.4KNm



Rear impact stress



Side impact displacement :

The most probable condition of an impact from the side would be with the vehicle already in motion. So it was assumed that neither the vehicle would be a fixed object. For the side impact the velocity of vehicle is taken 20 kmph and time of impact considered is 0.3 seconds as per industrial standards.

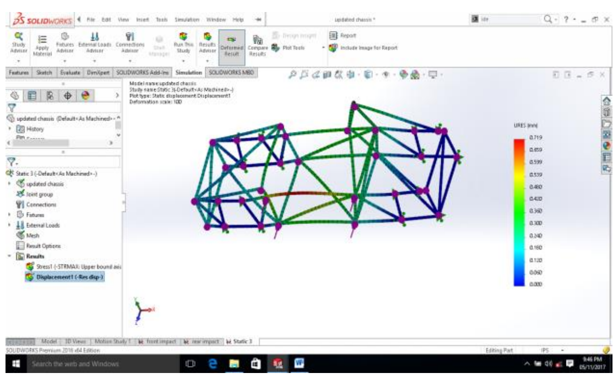
We know. According to Force work relation

Work done = Force * Displacement

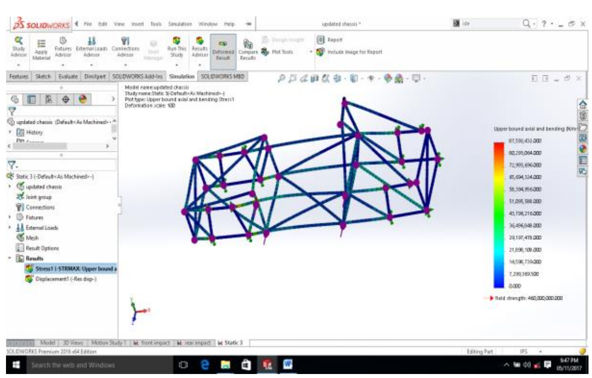
Force =4164 N

Displacement =2.499m

Work done = 10.4KNm



Side impact stress



CALCULATIONS

- **BRAKES:**

The brakes are one of the most important control components of vehicle. The brakes should be designed such that it should stop the vehicle within minimum distance in an emergency with considering safety of driver and vehicle itself. This report elaborates the braking system of our solar vehicle. With the mathematical calculations we have designed the brake system.

Calculations:

1. Pedal Ratio = A/B = 4:1

2. Rotor Disc Diameter = 200 mm

3. Wheel base (b) = 1651 mm

4. Track width (c) = 1244.6 mm

5. Force applied by Driver (F1) = 15 kg=147.15N

6. Velocity of vehicle (v) = 40kmph (Assumed optimum velocity)

7. Stopping Distance(S) =1.74m

8. Deceleration (Dx) =-35.468 m/s2

9. Stopping Time (t) = 0.156 sec

10. Braking force = 8867 N

11.Work Done in Braking = 15.428 KJ

10. Braking Power = 49.29 KWatt

12. Radius of tire (Rw) = 304.8 mm

13. Clamp load = 5.208 KN

- **STEERING:**

The basic aim of steering is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears. When the driver turns the steering wheel, a shaft from the steering column turns a steering gear. The steering gear moves tie rods that connect to the front wheels. The tie rods move the front wheels to turn the vehicle right or left.

COMPONETS:-

- Steering column
- Steering Rack
- Pinion Gear
- Steering Wheel
- Universal joints

ACKERMANN PRINCIPLE:-

Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii. The Ackermann steering geometry that is applied to all vehicles to unable the correct turning angle of the steering wheel to be generated when negotiating a corner or a curve.

- **CALCULATIONS:-**

Wheel base = 1651 mm

Track width =1244.6 mm

Steering ratio = 6:1

Camber angle = -2^0

Caster angle = 1^0

Ackerman angle =20.65^0

Steering angle of inner wheel=35^0

Steering angle of outer wheel =24.62^0

Average of inner and outer wheel angles=28.98^0

R1=2980.17 mm

Turning radius R = 3064.60 mm

- **SUSPENSION:**

The system of spring and shock absorber by which vehicle is supported on its wheels. The suspension system is made up of several components. Including the chassis which holds the cab of car.

The spring supports the vehicle weight and absorbs and reduces excess energy from road shocks along with the shock absorbers. Finally, the anti-sway bar shifts the movement of the wheel and stabilizes the car.

CALCULATION:

Weight of car with driver = 250kg

Front 2 tyres load =100kg=40%

Rear 2 tyres load = 150 kg=60%

Front 1 tyre weight and force=50 kg=496.5N

Rear 1 tyre weight and load= 75kg =735.75N

Wishbone calculation

Length of arms: 14 inches

Upper wishbone= 12 inches

Lower wishbone= 10 inches

Motion ratio (MR) =0.9154

Frequency (Nf) = 3.133Hz

Camber angle off set=-10 mm=-1cm

Tyre height= 17.038inch

Camber angle (ϕ) = -1.32°

Damper angle =30°

Caster angle=4°

Spring calculation

Modulus of rigidity(G)=78600N/mm^2

Mean diameter of coil (Dm) =33.3mm

Diameter of wire (d) = 6.7mm

Total no of coils (n) = 17

Diameter of spring coil (Do=Dm+d) =40mm

Spring index (c) = 4.97

Wahl's factor (k) = 1.312

Stresses in helical spring (τ) =181.43 MPa

Deflection front = 15.55mm

Deflection rear =23.328mm

- **Solar Panels:**

Solar Panels is basically "the most common way of harnessing energy from the sun through photovoltaic panels".

There are three types of solar cells

- Mono – crystalline Silicon solar cell
- Poly – crystalline Silicon solar cell
- Amorophous Silicon solar cell

We are going to use Mono – crystalline Silicon solar cell in our vehicle . In front side we are going to use 40 solar cells and in rear side 5 solar panels .40 cells will be connected in series on the front and 5 solar panels in parallel on the rear of the solar car.

1 Solar cells Specification :

Voltage : 0.5 V

Current : 8 A

1 Solar Panel Specification :

Voltage : 10 V

Current : 0.5 A

Front of the car:

1 solar cell : P = VI

= 0.5 * 8

=4WH

Voltage obtained : 20 V

Power obtained : 160WH

Rear of the car:

1 Solar panel : P = VI

=10*0.5

=5WH

Power obtained =25 WH

- **ELECTRICAL:**

Motor:

An electronic motor is an electrical machine that convert electrical energy into mechanical energy.

There are 2 types of motors

- BLDC motor
- Hub Motor

We are going to use BLDC motor.

Specification :

Voltage : 48 V

No load current : 5A

Rated current : 45A

Rated Speed : 3000±100 rpm

Rated Torque : 7.6 Nm

Max. Output Torque : 22 Nm

Rate Power : 2000W

Max. Output Power : 3000W

Efficiency : 83%

Number of Poles : 8

Motor diameter : 145mm

Insulation class : B

P=V*I

= 2000/48

=41.66 AH

Battery:

An electronic battery is a device consisting of one or more electro cells with external connection provided to power electrical devices . It's positive terminal is the cathode and negative is anode .

Specification :

Weight : 18 kg

Dimension: 620 mm*300 mm*100mm

Pack of cells :

Voltage : 48 V

Current : 78 AH

1 cell :

Voltage : 3.2 V

Current : 2.6 AH

Total Output Power

P =VI

= 48 * 78

P =3744 WH

Motor consumption :

Power = 2000 WH

Current = 41.66 AH

Remaining :

Power = 1744 WH

Current = 6.34 AH

Backup Time:

Tb = 3744/2000

=1.872 hr

Charging Time:

Ideal : Tc = 48/hr.

RESULT:

- **Chassis impact test:**

Front impact displacement:

Force =9611.2N

Displacement =1.08m

Work done = 10.3KNm

Rear impact displacement:

Force =4164 N

Displacement =2.499m

Work done = 10.4KNm

Side impact displacement :

Force =4164 N

Displacement =2.499m

Work done = 10.4KN

2. Brakes:

Braking force = 8867 N

Work Done in Braking = 15.428 KJ

Braking Power = 49.29 KWatt

3.Suspensions:

Front 1 tyre weight and force=50 kg=496.5N

Rear 1 tyre weight and load= 75kg =735.75N

4. **Solar Panels:**

Front of the car:

Voltage obtained : 20 V

Power obtained : 160WH

Rear of the car:

Power obtained : 25 WH

- **CONCLUSION**

This paper focus on the design, analysis and calculation of various components that is necessary for fabrication of a Electric Solar Vehicle. We have performed various types of static analysis and applied different loading condition on the chassis 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 chassis. Successful analysis was perform on the chassis of CAD modal using ANSYS WORKBENCH to determine, equivalent stresses, and total deformation results. The type of steering system used is rack and pinion and all the calculation are done using Ackerman's principle. Detailed calculation of brakes is discussed in this paper and the maximum temperature is evaluated using software. Thus, after all the calculations and analysis, it is finally conclude that this Electric Solar Vehicle is safe for fabrication under healthy engineering practices and meets the performance targets.

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