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Design and Fabrication of Hybrid Green Vehicle

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Abstract:
The Objective of the Vehicle Design team is to build an Eco friendly tricycle cycle on an assumption that a manufacturing firm has engaged to design, fabricate and demonstrate one for evaluation of the same as a product ready for production. The vehicle is tested for its cost analysis, overall design presentations, acceleration, braking, cornering capability, fuel economy and endurance. The main goal is to create a new design structure of pigeon head top frame for better aerodynamics, stress distributing base frame fish bone structure, ergonomically accessible features & utilization of solar panels at top frame. This cycle consists of two drive mode [1] mechanical [2] electrical mode of driving system with dual seat in the main compartment. Finally the vehicle could run at a recycling power of 45-50 min for a cycle & could achieve speed of 35 km/hr on road condition.

Keywords: *Acceleration, aerodynamics, endurance, design, ergonomics*

1. Introduction

The main purpose of this paper is to determine the best design for the new age of eco green vehicles that would provide maximum efficiency in consideration of fuel utilization. The vehicle consists of two drivers with pedaling mechanism and accelerator for driving the vehicle manually & electronically according to wish of the respective drivers. Here the mechanical energy is in turn converted in to electrical energy stored in batteries. These specifications were built under the SAE norms. For design and construction of vehicle solid woks was used, structural members were joined using weld-mends, weight saving is one of the major considerations of design with an additional feature of aerodynamic structure that enhances the better speed at minimum time with less energy utilization. The pigeon head structure enhances the speed with ease of air flow to enhance drag reduction with pitching movement. Fish bone base frame helps in equal distribution of stress for the applied load vertically; an additional feature of solar pane at the top frame will enhance the additional energy for power cycle by recharging the batteries added to pedaling by the two drivers. ASTM 4130 A grade material is chosen for vehicle fabrications that will in turn increases durability and weight reduction, BLDC ½ BHP motor of 400w power is used for better performance.

1.1. Technical Specifications

The frame has been designed considering the location of suspension points to ensure optimum load paths, the space required for different components, and compliance to rules. Ample space is provided for driver cell, providing space for, battery, ensuring driver's comfort and easy egress. ASTM 4130 Grade mild steel is used which is appropriate for frame due to its availability, machine ability and ease of fabrication. It is resistant to scaling and oxidation and has a clean, smooth finish. a slight variation in the frame is to be made instead of fishbone structure having cross bars, we have made the straight bars. By slight change, the stability of the vehicle does not change. As mentioned above, we have made the frame according to the specification in accordance to table[1]. Determination of the suspension parameters was a bit taxing. One of the most difficult parts of designing a suspension system is compromising

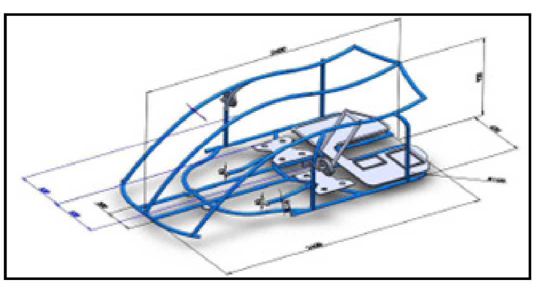


Figure 1: Showing Roll cage view

1.2. Suspension

The suspension is one of the most important components in any automobile and the key to every design enunciates from here. It comprises of wishbones & spring.

SNO	PARAMETER	DESIGN	SIZE & SPECIFICATION
	FRAME		
1	a. Track width	-	Max 1150
	b. Wheel base	-	Max 1180
	c. Whole base	-	Max 2430
	POWER TRAIN		
2	a. Shaft	-	1m Length
	b. Bearing	20 mm	1d 20mm
	c. Chain	-	4set
	d. Sprockets	-	4(18teeth)
	e. Pedals & Sprockets	-	2(48teeth)
	WHEELS		
3	a. Front wheels	26”	26”
	b. Rear wheels	28”	28”
	ELECTRICAL SYSTEM		
4	a. Motor		
	b. Battery	1	400 w
		1	48 v

Table 1: Showing the various components specification

SNO	PARAMETER	OBTAINED VALUE
1	Diameter of spring wire d	1
2	Mean coil diameter D	80 mm
3	Number of active coils N	6
4	Shear modulus G	79.3×10^{3} Mpa
5	Spring force F	5000 N

Table 2: Showing the spring parameter

SNO	DESCRIPTION	VALUES
1	Steering radius	3.75:1
2	Turning radius	3.96 mm
3	Lock to lock angle	180^{0}
4	Max turn angle	30^{0}

Table 3: Steering specification

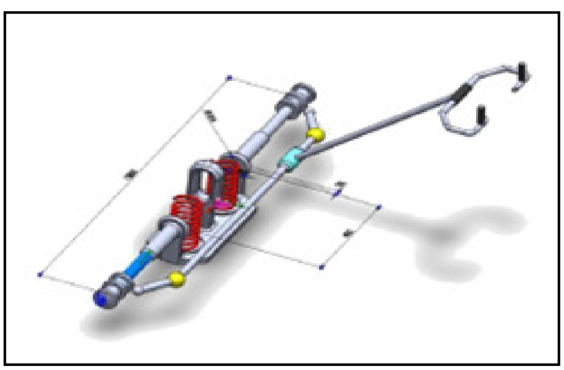


Figure 2: Steering overview

1.3. Steering

An efficient steering system is very essential for better and smooth handling of any vehicle. We have selected Rack and Pinion type steering system because of its simple design, compactness and easy availability. . Due to its simple design as compared to other types like re-circulating ball, worm and sector etc. its mounting becomes easier and weight

Gets reduced because of less number of linkages used. Understanding the importance of steering system we have tried to achieve 100% efficient Ackerman principle

Figure 3: Vehicle overview

1.4. Tyres and Wheels

Wheel end is one of the main aspects to be considered for proper motion of the vehicle in case of a tad pole configuration (2F & 1R) as it houses the main mounting points of steering, suspension and brakes with the wheel in a vehicle. The wheel end is made up of the following parts- Rim, Hub, Disc, Milled bearing, and upright in sequence. Their compatibility with each other is a major design issue as these parts have been taken from different sources. Larger and broader tire is used for better grip and better Traction.

SNO	DESCRIPTION	VALUES
1	Density	27 g/cc
2	Hardness	95 Brinell
3	Modulus of elasticity	68.9 Gpa
4	Ultimate tensile strength	607 Mpa

Table 4: Tyre specification

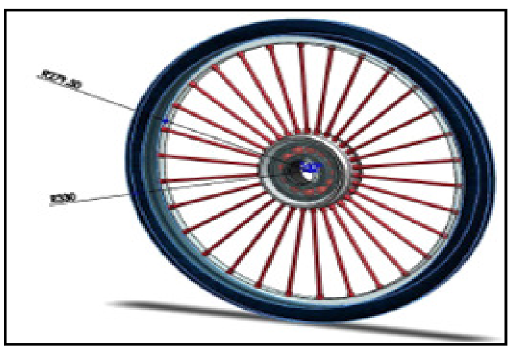


Figure 4: Showing the tyre

1.5. Power Train

The drive train consists of a 14 tooth front sprocket,40 tooth rear sprocket, and 520 series X-ring chain. The Rear sprocket is connected to a custom rear bearing case through differential transmitting torque drive shafts power train in the central part.This setup provides a reliable and simple method of transferring power to the rear wheels while minimizing losses.

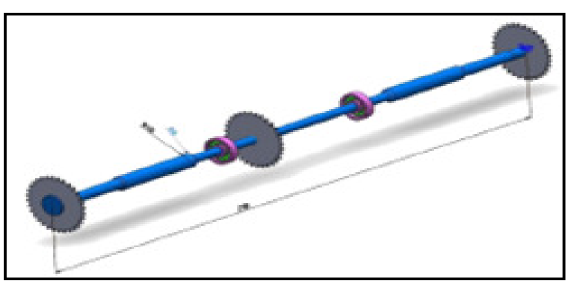


Figure 5: Showing the sprocket with drive shaft

SNO	SPROCKET	REDUCTION RATIO	VELOCITY OF THE WHEELS (KMPH)
1	1	1:1.4	35

Table 5: Showing Reduction ratio

1.6. Control of BLDC Motor

Since the controller must direct the rotor rotation, the controller requires some means of determining the rotor's orientation/position (relative to the stator coils.) as shown in figure[5] ,Some designs use Hall effect sensors or a rotary encoder to directly measure the rotor's position. Others measure the back EMF in the un driven coils to infer the rotor position, eliminating the need for separate Hall effect sensors, and therefore are often called sensor less controllers.

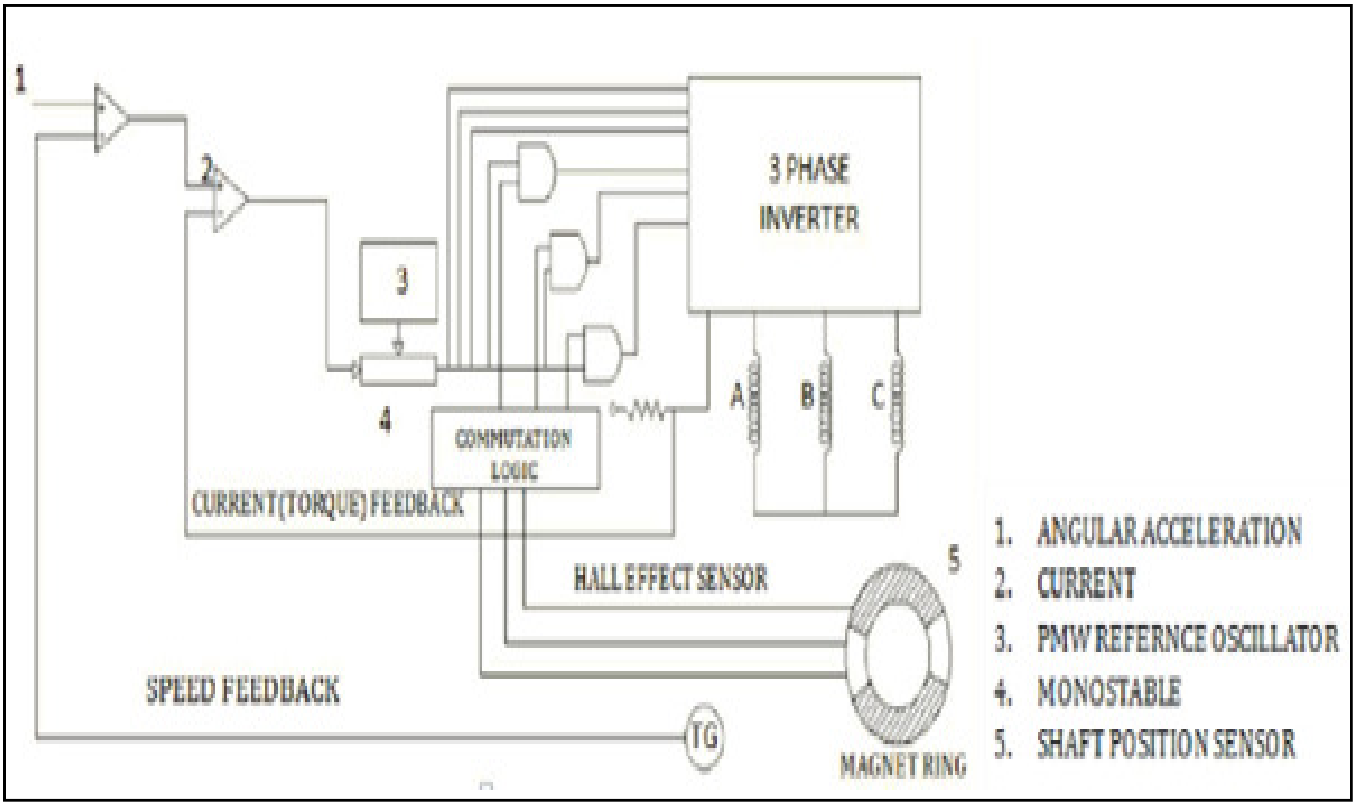


Figure 6: Showing the BLDC motor block diagram

<u>1.6.1. Battery Calculations</u>

Battery Backup = Battery Ah *(Volts/Load) *(1/Power factor)
Load = 400 W
Power factor = 1.4
Voltage = 12 V
Battery = 35 AH
The battery backup
= 35*(12/300)*(1/1.4)
= 35*0.04*0.7
= 1hour
This is impossible in real time, so it is assumed to be 45-50 min

1.7. Safety & Ergonomics

Ergonomics, or the study of human-machine interfacing, is important because the ultimate control of the vehicle belongs to the driver. Poorly Placed controls mean the driver must lose concentration on the race, and instead focus on the cockpit.

1.8. Body Panels & Aesthetics

Aerodynamics is the study of forces generated by motion of air on moving body. Aerodynamics is often described as a black art, the real secret to success on the track. In the tough struggle for crucial second aerodynamics play a major role. So in a cycle racing small difference in aerodynamics design makes the success or failure of a vehicle But the consideration of the former is to reduce the drag force and increase the friction in between the wheel base and the track to attain maximum acceleration this done to achieve a speed of 20-30 km/hr. The table [6] shows the various simulations of the former vehicle with part description.

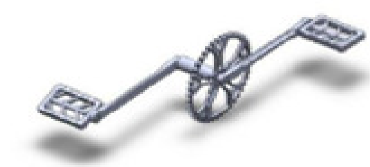
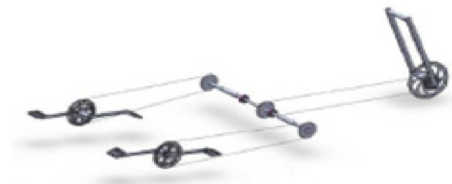
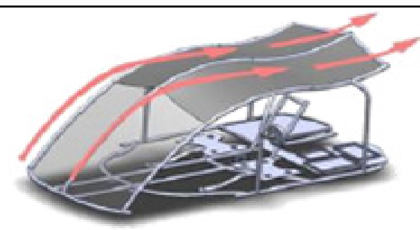
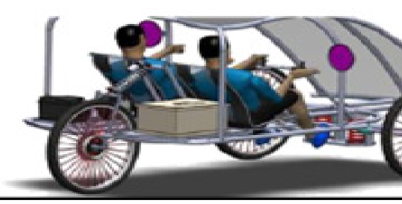
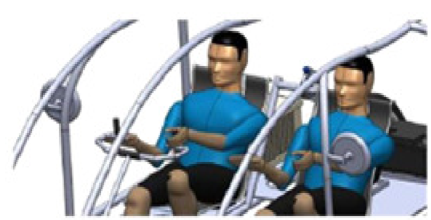
S. NO	PARTS	DRAWING
1	**PEDALS** Design is such that the calf portion of the leg is probably not be at less than120 degrees.	
2	**DRIVE TRAIN** Drive shaft is arranged in a way	
3	**SEATS** Foam seats are utilized according to the required constrains.	
4	**THE DRIVER'S LINE OF SIGHT** The goal in our design is to ensure enough of the race track in front is visible, and enough of the action to left and right is visible.	
5	**DRIVER COMFORT** The driver compartment is structured in a way comfortable for the drive.	
6	**DRIVER VISIBILITY** Driver has a good part of a front side view through the transparent shield of view.	

Table 6: Showing the various Ergonomics vehicle view

2. Aerodynamics

Cx0 = Fx/(q*Sref)= 19.90 ρ= 1.27*Vg /(m3) V= 8.333m/sec Sref= 0.3429m2 Fx = Axial force on a wheel = 300N	

Table 7: Showing the Aerodynamic Calculation

2.1. Vehicle Dynamics

1. Mr/M = Ψ = 140/300 = 0.466 Mr = Static rear axle load M = total vehicle mass Ψ = Static axle load distribution	2. h/w_b = X = 0.54/1.65 = 0.3272 h = Vertical distance from C of G to ground level (m) w_b = Wheel base (m)= 1650mm = 1.65m X=Relative centre of gravity height
3. (1-Ψ) + (X*a) * M = M_{fdyn} 1-0.466 + 0.3272 *300 =M_{fdyn} M_{fdyn} = 258.36 Kg a = Deceleration (g units) M = Total vehicle mass (Vg) M_{fdyn} = dynamic front axle load (Vg)	4. BF = M*a*g = 300*0.3215*9.81 = 946.25 N BF = Total braking force (N) M = Total vehicle mass (Vg) a = decelaration g = acceleration due to gravity (m/s^2)
5. S = V2/ (2*g*a_{avg}) -0.3146 = 5.55/ (2*9.81*a_{avg}) a_{avg} = -0.3146 m/s2 S = Stepping distance (m) V = Test speed (m/sec) a_{avg} = average deceleration for the whole	6. a_{avg} = V/ { (V/a) – 0.3*g } -0.3146 = 5.55 / { (5.55/a) – 0.38 } a = -0.3215 m2/s V = Test Speed (m/sec) a = deceleration g = acceleration due to gravity (m/s^2)

Table 8: Showing Vehicle dynamics

2.2. Innovation

- Fish bone structure used in the frame with little deviation instead of using cross members we use straight members it result effective stability.

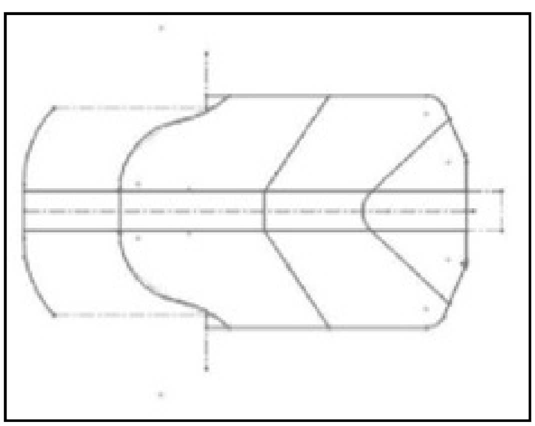


Figure 7: fish bone frame

- Steering system used here is Ackerman system with joystick control.

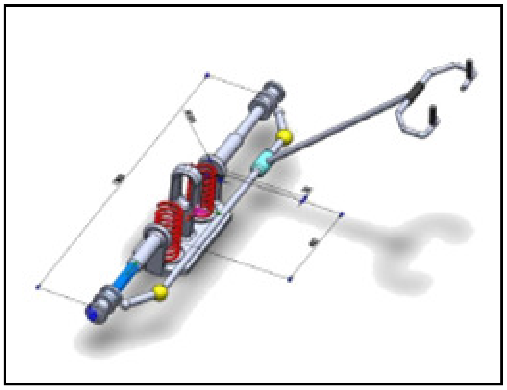
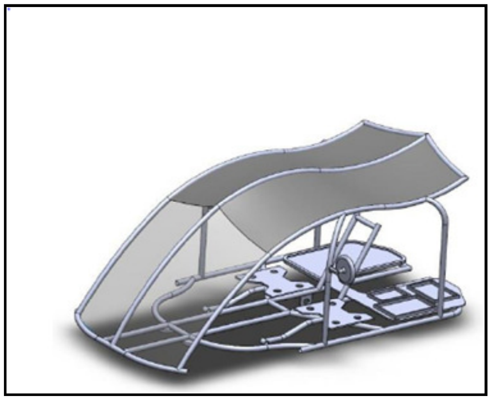


Figure 8: Steering model

- Solar panels can be utilized at the top frame in future for conserving the fuel.



.Figure 9: Showing top solar frame

- Pigeon head structure is used to reduce the drag and increase aerodynamic effect.

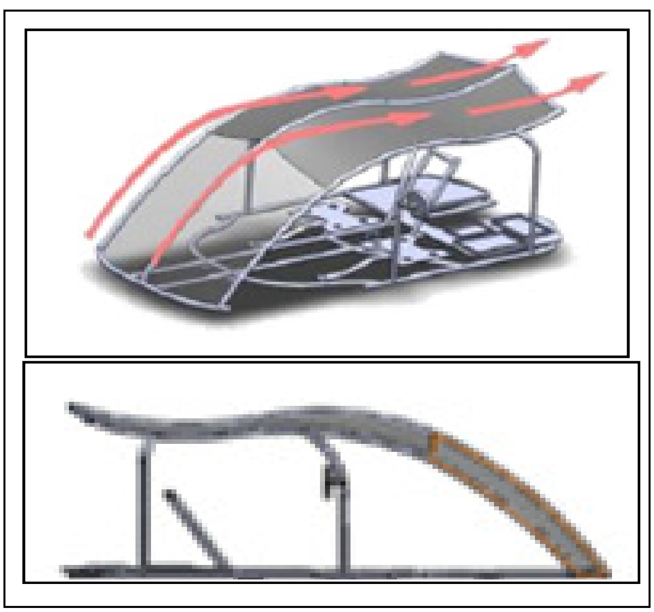


Figure 10: Pigeon head structure

2.2.1. Review of the Vehicle & Analysis

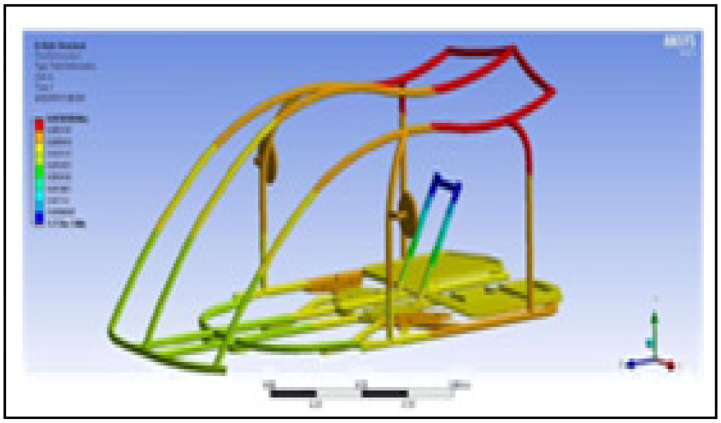


Figure 11: Showing deformation results

The figure [10] shows the deformation of figures with the various deformation value found to be 5.8 mm ,Von mises Stress 178 Mpa , Volumetric Strain 0.0009, Factor of safety 3.25,During the frame analysis the structural members were meshed

Figure 12: Showing the mesh view

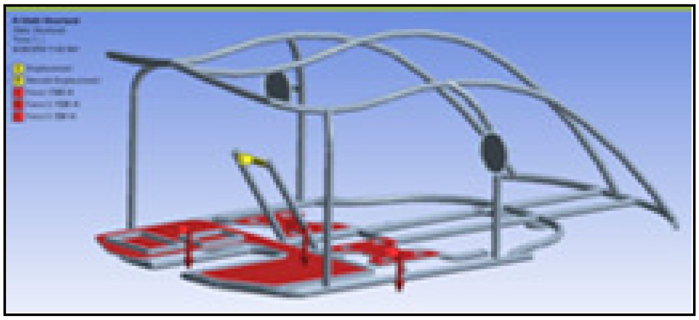


Figure 13: Fixed boundary condition

Hence an optimum loading condition of 1500 N on each support of the seat 300N on rear member were applied for stress and strain deformation results shown according to the polarity these mesh layers help in find the stress and strain deformation for the applied loading condition for the rool of cage (solid weld mends)

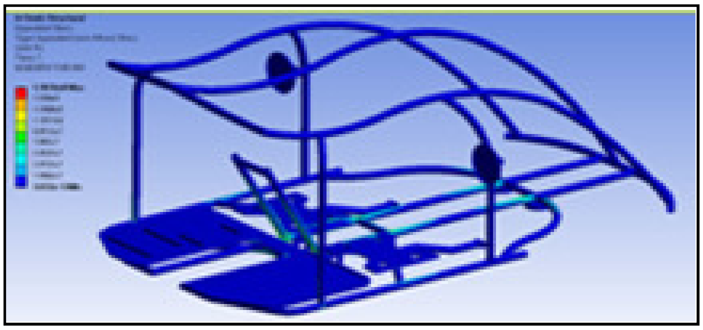


Figure 14: Von mises stress

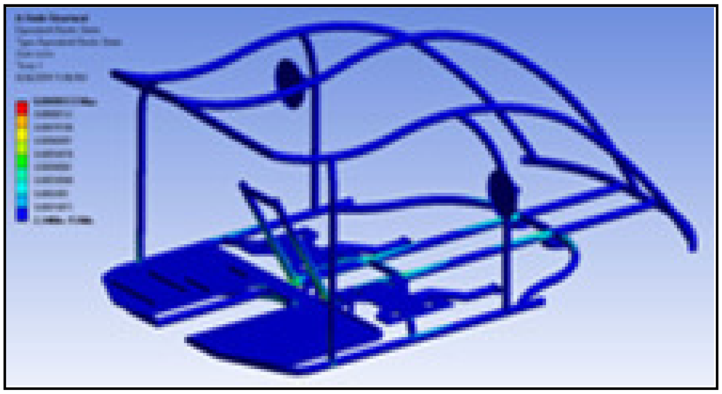


Figure 15: Volumetric strain

2.3. Design of View

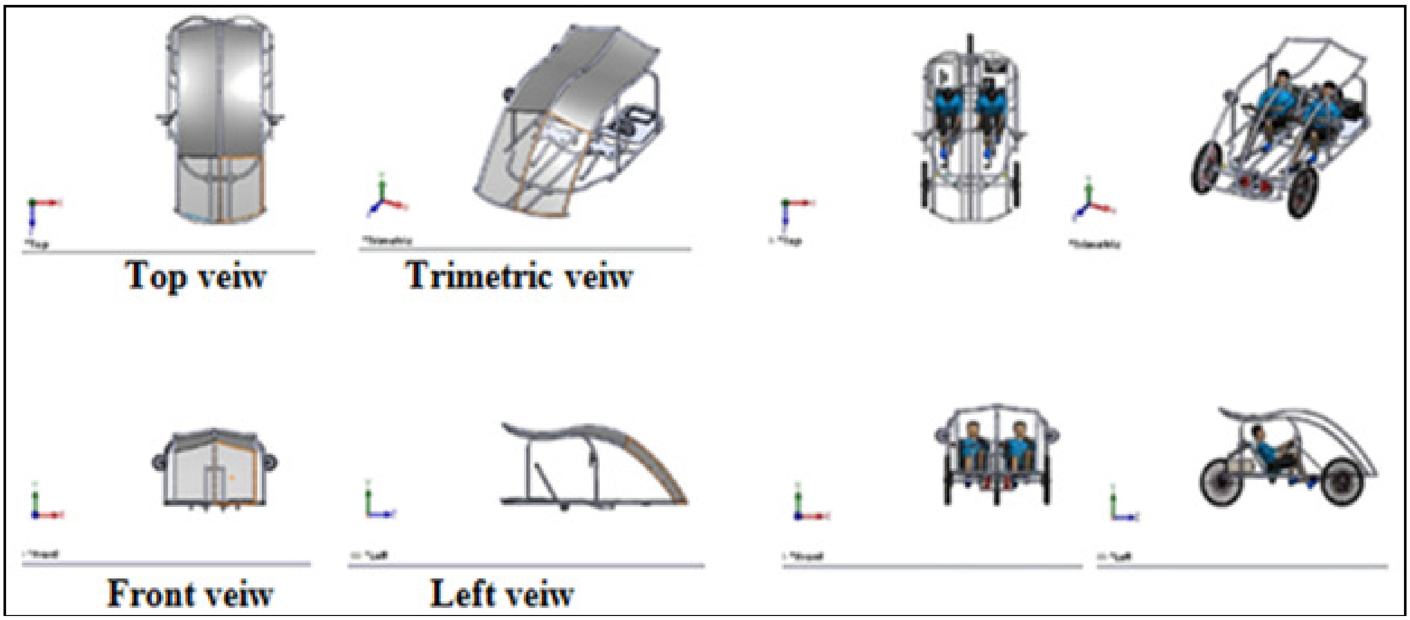


Figure 16: Showing simulated views

Figure 17: Showing the real time model

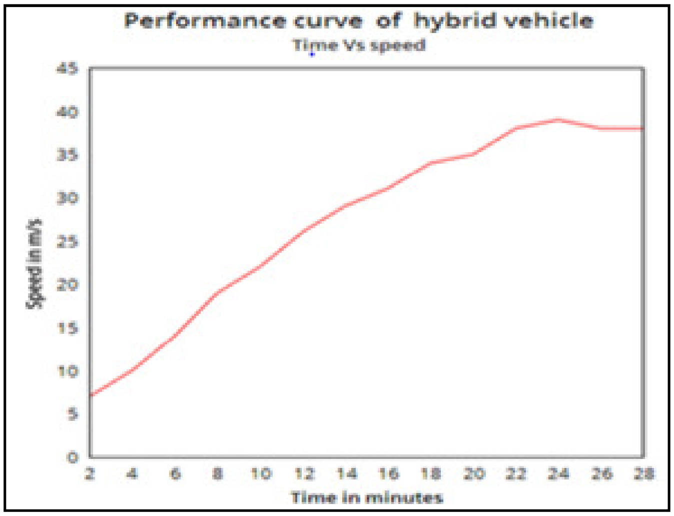


Figure 18: Showing performance curve

3. Conclusion

- From our investigation we have concluded that from ANSYS the results for the roll of cage in consideration applied load of 1500 N on each support of the seat with constrains
  - The von mises stress = 178 Mpa
  - Volumetric Strain = 0.0009
  - Factor of safety = 3.258
  - Total deformation = 5.8 mm
- In real time model the vehicle has a recycling power and can run up to 45-50 min (with battery usage) for a cycle & could achieve speed of 35 km/hr on road conditions.
- Solar panels can be used at top frame instead of acrylic sheet which can be converted into in electrical energy to recharge battery during rides.

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