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Conceptualization, design and modeling of hybrid golf car

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Abstract
An electric vehicle is pollution free and is efficient at low speed conditions mainly in high traffic areas. This project is mainly focused on an idea about hybrid solar golf cart technology which solves the major problem of fuel and pollution in present days. A 'hybrid golf car' is a vehicle which depends not only on electricity to recharge the batteries but also on a solar panel which would provide the necessary current to charge the batteries. The average weight of the car would be about 200 kg approx. and it would carry the load of 450 kg with a maximum speed of 25 km/h. A parametric model of chassis of Hybrid Golf Car is modeled using CATIA V5R20 software. Investigate the stress by analyzing the steel (AISI 1016) connecting rod and find out the maximum stresses generated and optimize the weight.

Keywords: Photovoltaic panel, CATIA V5R20 for solid Modeling, ANSYS 13.0 for Stress Analysis, FEA, Optimization

1. Introduction

Around 93% of today's automobiles run on petroleum based product, which are estimated to be depleted by 2050. Moreover, current automobiles utilize only 25% of the energy released from petroleum and rest is wasted into the atmosphere. For preservation of gasoline for future and increasing the efficiency of vehicle an electric vehicle can be a major breakthrough. The objective of this project aims at better utilization of fuel energy and reduces dependence on non-renewable resources. Determine how feasible widespread change to hybrids would be in future with all information taken into account, concluded that hybrids have several advantages as fuel efficient, low pollution. The objective is to design and fabricate a hybrid golf car powered In Hybrid golf car, the battery alone provides power for low speed driving conditions.

The car would consist of a battery bank of 4 batteries each of 12V, 120Ah which would drive a 1.2kw D.C motor at 3000r.p.m for 3 hours when fully charged. It also utilizes the concept of charging the battery by using 12V, 300W solar panel and a charge controller which would charge the batteries from 0% to 100% in 6 hours.

1.1 Improvement

A photovoltaic panel is also used in addition to the plug in facility to charge the battery. An alternator is attached to the front axle of the car, which would generate electricity to charge the battery, which would reduce the recharging time of the battery.

2. Formula used

The global formula to\ estimate the electricity generated in output of a photovoltaic system is:

$$E = A \times r \times H \times PR$$

E = Energy (kWh)

A = Total solar panel Area (m^2)

r = solar panel yield or efficiency is the yield of the solar panel given by the ratio: electrical power (in kW) of one solar panel divided by the area of one panel

H = Annual average solar radiation on tilted panels (shadings not included between 200 kWh/m^2.y (Norway) and 2600 kWh/m^2.y (Saudi Arabia).

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75) PR (Performance Ratio) is a very important value to evaluate the quality of a photovoltaic installation because it gives the performance of the installation independently of the orientation, inclination of the panel. It includes all losses

3. Mathematical modeling

Drive wheel motor torque calculation

Total tractive effort = rolling resistance + Gradient resistance + force per acceleration.

Now,
Gross vehicle weight (GVW) = 485lb = 220 kg.
Weight of each drive wheel = 12lb = 55.38kg.
Radius of wheel (Rw) = 7inch.
Desired top speed (Vmax) =30km/hr = 8.33m/s = 27.34feet/sec.
Desired acceleration time = 5sec.
Max. Inclination angle (α) =2degree
Worst working surface = concrete, asphalt

1. Rolling resistance =GVW×Crr where, Crr= surface friction
   = 485 x .01
   RR =4.85lb = 2.19kg
2. Gradient resistance (GR)= GVW sin α
   = 485sin2 =16.92lb
3. Acceleration force (Fa) =(GVW x Vmax.)/32.2(Ft/s^2 x Ta(sec.))
   = 485 x 27.34/ 32.2 x 1
   = 411.7lb

Now,
Total tractive effort = RR + GR + Fa
= 4.85 +16.92 + 411.7
= 433.56lb = 196.6kg

Now,
Wheel torque (lb-inch) = tractive effort x Rw x Resistance factor
= 433.56 x 7 x 1.15
=3336.4lb-inch
= 376.96N-m

3.1 Reality check

To verify that the vehicle can transmit the required torque from the drive wheel to the ground:
Max. Tractive torque (MTT) = Weight on drive wheel x coeff. of friction x wheel radius
= 122 x 0.5 x 7
= 427lb = 48.24N-m
Max. active torque = 427 x 4
= 1708lb-inch
= 192.97N-m

<Total wheel torque = 3336.4lb-inch
= 376.96N-m

Note: MTT represents a max. amount of torque that can be applied before slipping occurs for each drive wheel.
Required power (H.P) = Rt x Vmax. / (3600 x ηt).

= 192.97 x 30 / (3600 x .85)
= 1.89 hp = 1411 W

5. Chassis design

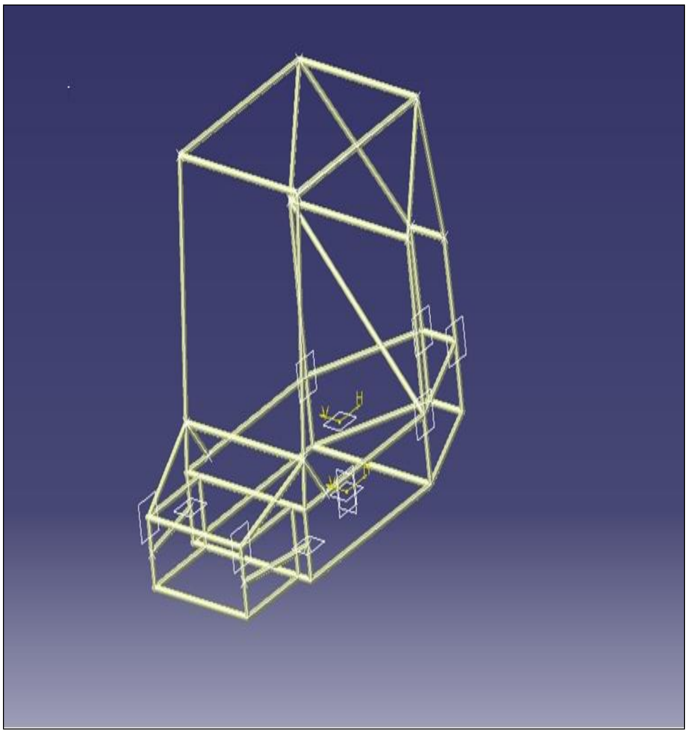


Fig 1: Isometric view

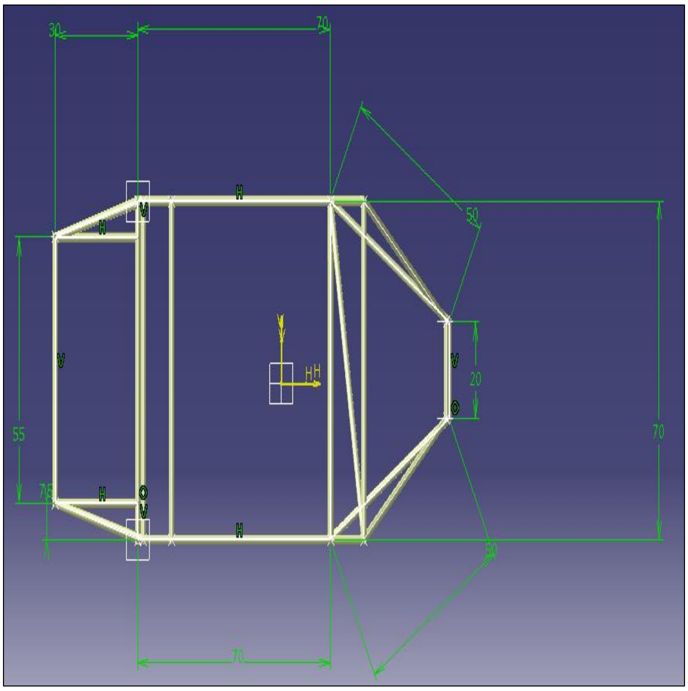
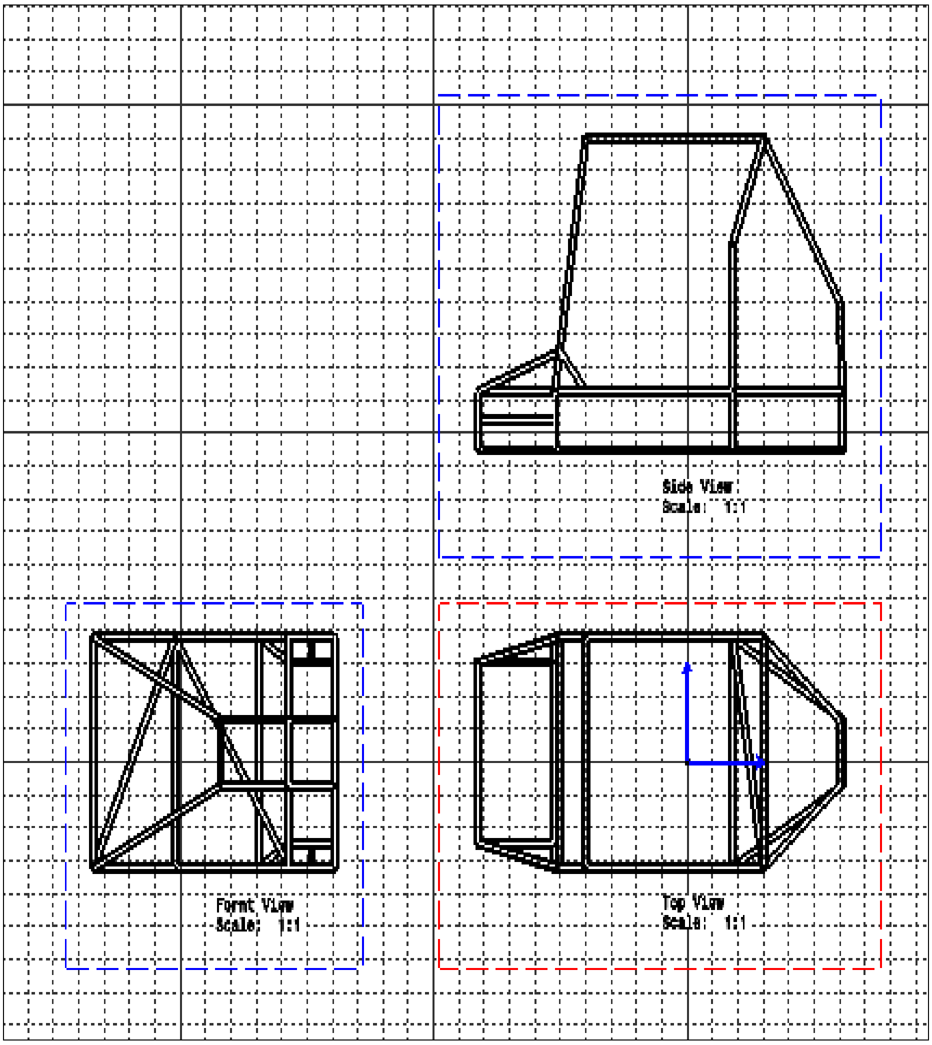


Fig 2: Top view with dimensions (in inch)



5. Material Specification

AISI 1016 Steel, cold drawn, 19-32 mm (0.75-1.25 in) round

Physical Properties	Metric	English	Comments
Density	7.87 g/cc	0.284 lb/in³	

Mechanical Properties	Metric	English	Comments
Hardness, Brinell	121	121	
Hardness, Knoop	140	140	Converted from Brinell hardness.
Hardness, Rockwell B	68	68	Converted from Brinell hardness.
Hardness, Vickers	126	126	Converted from Brinell hardness.
Tensile Strength, Ultimate	420 MPa	60900 psi	
Tensile Strength, Yield	350 MPa		

AISI 1016

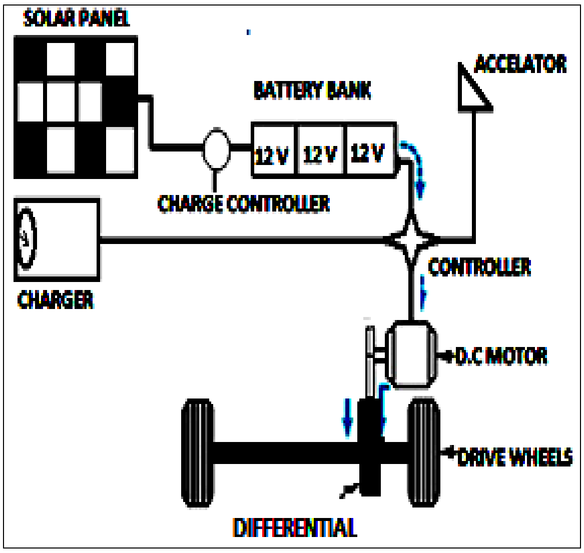
First figure indicates the major class of steel. Second figure indicates a sub-division of the major class and the percentage of the major alloying elements. This is true of many of the alloy steels. The third and Fourth figures are most important for welding because they indicate carbon in hundredths of a percent

Chemical composition

Table 1: The chemical composition of AISI 1016 carbon steel is outlined in the following

Element	Content (%)
Iron, Fe	98.13-99.58
Manganese, Mn	0.60-0.90
Carbon, C	0.12-0.18
Sulphur, S	≤ 0.050
Phosphorous, P	≤ 0.040

6. Working principle



1. PV panel 12V, 300W convert sunlight into electricity, which is stored in batteries. Then its energy will be utilized for hybrid car propulsion.
2. Battery bank of 4 batteries 12V, 105Ah each is an important component for the HSC. It will generate 48 V DC for supplying to the electric motor and also electronic devices in the HGC.
3. Electric motor has been employed for driving the hybrid golf car. However, we can observe that the brushless DC motor is often operated in the over the classical DC motor due to long lifetime operation, high speed and also high torque.
4. A charge controller of 20A is installed between the solar panel and the battery bank which would prevent the overcharging of the batteries.
5. Electronic controlling unit (ECU) is an electronics circuit that is used for controlling the energy in the electric motor which can be provides a speed variation.

7. Transmission system

In this hybrid solar car, we are using rear wheel transmission system - The electric motor is placed near the rear axle of hybrid solar car which can be operated by charged batteries then electric motor rotate the rear axle of rear wheels.

Both systems (solar panel & battery bank) are placed in hybrid golf car, initially the battery is charged to 100% by electricity and then brought in use. As the motor discharges the battery, it is further charged up through the solar panel.

8. Conclusion

The use of solar energy for personal mobility seems ripe for passing from prototypical applications to commercial products. The integration of photovoltaic panels in electric and hybrid vehicles is becoming more feasible, due to the increasing fleet electrification, to the increase in fuel costs, to the advances in terms of PV panel technology, and to the reduction in their cost. Hybrid Solar Vehicles may therefore represent a valuable solution to face both energy saving and environmental issues. Of course, these vehicles cannot represent a universal solution, since the best balance between benefits and costs would depend on mission profile: in particular, significant reductions in fuel consumption and emissions can be obtained during typical use in urban conditions during working days. Moreover, the integration with solar energy would also contribute to reduce battery recharging time, a critical issue for Plug-in vehicles, and to add value for Vehicle to Grid applications Putting a solar panel on an existing hybrid vehicle may be just the first step: in order to maximize their benefits, redesign and optimization of the whole vehicle-power train system would be required. Particular attention has to be paid in maximizing the net power from solar panels, and in adopting advanced solutions for power electronics. Moreover, these vehicles would require specific solutions for energy management and control, whit more advanced look ahead capabilities.

The adoption of moving roofs for parking phases and the use of solar panels on windows and lateral sides would enhance solar contribution, beyond the classical fixed panel on the car roof. Moreover, these solutions would reduce the gap between solar contribution at low and high latitudes, so extending the potential market of these vehicles. Interesting opportunities are also related to possible reconversion of conventional vehicles to Mild Hybrid Solar Vehicles, by means of kits to be distributed in after-market.

The perspectives about cost issues of PV assisted vehicles are encouraging. Anyway, as it happens for many innovations, full economic feasibility could not be immediate, and a financial support from governments would certainly be appropriate. But the recent and somewhat unexpected commercial success of some electrical hybrid cars indicates that there are grounds for hope that a significant number of users are already willing to spend some more money to contribute to save the planet from pollution, climate changes and resource depletion.

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