Optimal Design, Simulation and implementation of Solar Photo-voltaic Panels in Hybrid electric vehicles using CATIA V5R19 software integrated with ANSYS 13.0 versions

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Abstract. The primary motive of this research investigation is to explore out by enforcing the sun powered energy in the present hybrid electric vehicles, which signifies precipitous plummet in pollutants and harmful contaminants of environment. Solar powered coercing vehicles are environmental friendly however can’t attain to most reliable speed in certain specific time-interval. The operational functioning of two dissimilar fuels collectively may be one of the most advantageous aspects of this novel concept. CATIA V5R19 is appropriate podium for the design outlining of vehicles which this particular research study is aiming. After analyzing the blueprint layout, for computation or estimating of forces, load, internal resisting force and lateral strain performing at the front and rear collisions of structural body-on-frames, ANSYS 13.0 version platform was utilized for software primarily based modeling and simulation. Output statistics or facts figures are premeditated to determine the technical factors of solar powered hybrid vehicles. Solar hybrid electric vehicles have high competencies of an overall recital as its enormous arrangement of traditional fuel engine, possesses high powered electric-vehicle-battery & solar photo-voltaic panel modules.

Keywords: SHEV (Solar powered hybrid electric vehicles), HEV (Hybrid electric powered vehicles), CATIA V5R19 software, ANSYS 13.0 version, EOS (Electrical operated system), PV (Photo-voltaic panels).

1. Introduction

Need of studying alternative fuels vehicle became necessary due to increment in pollution and fuel consumption. That is why I assigned concept of hybrid solar car to bring some change in today’s era and to create environment friendly as well as user friendly vehicle. My research has strong potential to decrease global warming along with lesser fuel consumption. By this research capability of two different energies can be measured, one is regenerative braking energy and another is solar PV energy. Both powers will work together or either in place to drive an engine. Engine size of hybrid car is less which can be help full to decrease overall weight of vehicle by 12%. Solar plates will be attached at few places and balancing of overall weight of vehicle becomes possible. The core objectives of this present research study were written as mentioned below:
• Reduction in higher demand of fuels like petrol or diesel
• Carbon dioxides and monoxides emission should be decreased to keep environment clean
• Minimum trouble of pollution in urban areas

2. Research Methodology
Figure 1 shows the research methodology in order to carry out the design and analysis of Hybrid Solar powered electric vehicle as illustrated below:

![Diagram of research methodology]

3. Experimentation: Components, Design and Analysis

3.1. Main components of Hybrid Solar powered Electric Vehicle:

a) **Hybrid electric vehicle and solar powered vehicle is generally consisting six elements:** The core parts used in the fabrication, design and analysis of a Hybrid Solar powered Electric Vehicle were Electric powered motor, Photo-voltaic panels, Electric powered generator, Battery unit, internal combustion Engine and digital manipulate Unit as shown below in fig.2.
Fig. 2. Main components of Hybrid Solar powered Electric Vehicle

Photo-voltaic (PV) panel converts sun rays to electricity, which energy can be stored in battery. Upon need we can get the energy from battery to drive the vehicle.

Electric motor is special equipment which can rotate in two directions. When it works in one direction it supply energy from generator to battery. When it is working in opposite direction it receives energy from battery and uses it to drive the vehicle.

Electric generator is capable of generating electrical energy by means of mechanical energy produced during vehicle braking or slope on road.

Battery Unit is going to be very important unit for hybrid solar vehicle. Battery can generate 24V DC to electric motor.

Internal Combustion (IC) engine can be useful to drive the vehicle especially at night time or when battery has less energy stored.

Electronic controlling Unit (ECU) will control the variation of different sources of energy to drive the vehicle. It will decide at what time which source of energy will be most suitable to drive the vehicle.

b) **Transmission System:** Transmission which is going to be used for this research investigation is illustrated in fig. 3 as mentioned below:

Fig. 3. Power Transmission mechanism used in the design of Hybrid Solar powered Electric Vehicle
3.2. Model and Design:

The best place to fit the solar panel is at roof portion of the car, along with that the space of bonnet and boot has also been utilized.

The design of solar photo-voltaic panel on the roof portion of the vehicle is carried out by using CATIA V5R19 platform. Firstly the frame-work has been created and then several different parts like solar panel, IC engine, wheels and axles, braking system, transmission etc has been fabricated. Following figures 4 & 5 represents the design model of Hybrid Solar powered Electric Vehicle as mentioned below:

![Fig.4. Drawing and Drafting of Hybrid solar Car](image1)

![Fig.5. Different View of Hybrid solar car](image2)

3.3. Design of Photo-voltaic system:

Factors affecting the plan-layout of Photo-voltaic panels are written as follows:

- Magnitude of load coming on vehicle.
- Energy requires overcoming the load and driving the vehicle.

**Driving Time:** Magnitude of energy generated while car is in moving condition can be calculated by,

\[ E_d = \eta_p \times A_p \frac{h_{sun}}{e_{sun}} \]

**Parking Time:** While applying brake of parking, the vehicle total energy produced can be obtained by following formula,

\[ E_p = \eta_p \times A_p \frac{h_{sun}}{e_{sun}} \]

Where \( \eta_p \) = Photo-voltaic panel efficiency, \( A_p \) = Photo-voltaic Surface area, \( e_{sun} \) = Average each day strength captured by solar panel (4.3 K hrs/day), \( h_{sun} \) = Solar powered detained at some point of a sun at (7:00 AM to 7:00 PM), and \( h_d \) = Solar powered at some stage in a parking time.

Overall Energy = (Driving time + Parking time)

\[ E = E_p + E_d \]
3.4. Proposed design layout of Battery system:
Here we're counting intensity of discharge is by using 75%. Amendment of Temperature might be taken into consideration as battery efficiency decreases at a little temperature. Battery pecuniary capability in Ampere hour (Ah) is given through:

\[ B_{rc} = \frac{E_c \times \text{Ah} \times D_s}{\text{DOD}_{\text{max}} \times \eta} \]

Where, 
- DOD = Battery depth of discharge
- \( D_s \) = Battery autonomy or storage days
- \( \eta \) = Temperature alteration aspect = 0.910
- \( E_c \) (Ah) = Energy/load is specified with the aid of Ampere in hour

Batteries in parallel is given by means of,

\[ B_p = \frac{B_{rc}}{B_{sc}} \]

Where-in, \( B_{rc} \) = Power of assorted battery (Ah)

Power source, Batteries in series is given by using way of,

\[ B_s = \frac{V_n}{V_s} \]

In which, 
- \( V_n \) = Nominal voltage of power source
- \( V_s \) = Nominal voltage of device

Overall battery depository of appliance is given by,

\[ B_T = B_p \times B_s \]

3.5. Modelling, Simulation & analysis of framework enclosed casing of Hybrid sun powered vehicles:

The stress analysis has been carried out on the frame by using finite element method with ANSYS software. Modelling is followed for front and rear part structural chassis/frames 3D brick element (Solid 45) and five-node. Analysis is also conceded out for hybrid solar vehicle frame which can withstand maximum load & shear stresses for every segment of vehicle deliberated. The maximum load and shear stresses beside the bonded adhesive layer for glass/epoxy were deliberated diverse collision as revealed from the fig.6 to fig.10:

![Fig.6. Displacement of rear-collision](image-url)
Fig. 7. Front collision of car frame collision

Fig. 8. Von-Mises elastic-strain showing front collision of vehicle

Fig. 9. Von-Mises elastic strain showing rear collision of car
4. Results & Discussions

4.1. Common widespread Dimensions
The measurement and design aspects of several components of Hybrid Solar powered Electric Vehicle is shown below in table 1.

| S.No. | Dimensions of hybrid sun powered based vehicle | Length (mm) |
|-------|-----------------------------------------------|-------------|
| 1     | Wheel pedestal                                | 2818 mm     |
| 2     | Wheel trail                                   | 1165 mm     |
| 3     | Altitude of vehicle                           | 1226.46 mm  |
| 4     | Ride Height                                   | 285 mm      |

4.2. Absolute energy produced by Photo-Voltaic panels:
Overall Area of Photo-voltaic panels = 835401 mm² = 0.835.401 m²
Number of panel installed in roof = Three, single-single panel installed in hood & back-side of vehicle
Absolute energy produced through panel = (No. of Photo-voltaic Panels × Energy) = (5×150 W) = 0.75 kW

4.3. Battery requirement in Device
The prerequisite condition of power-source, battery used for the design of Hybrid Solar powered Electric Vehicle is shown below in table 2.
Table 2. Battery requirement for the draft-plan layout of Hybrid Solar powered Electric car

| Potential of Required through load | 2 KW |
| Ability/Limit of battery (Ah) | 5 Ah |
| Power sources in parallel arrangement | 1 |
| Power sources in series arrangement | 4 |
| Overall Number of battery | 4 |
| Energy/intensity of batteries | 220-240 watt |

4.4. Front and Rear frame analysis of Solar Hybrid Vehicle:
The Head-on and Rear-ended structural frame analysis of Hybrid Solar powered Electric Vehicle is shown below in table 3.

Table 3. Front and Rear structural frame/chassis analysis for the draft-plan layout of Hybrid Solar powered Electric car

| Forms of impact of hybrid sun powered vehicle | Maximum displacement (mm) about the trial assessment pivot-axis | Von-Mises maximum distortion energy recovered strain | Von-Mises equivalent internal resisting force (MPa) |
|---------------------------------------------|---------------------------------------------------------------|------------------------------------------------------|--------------------------------------------------|
| Head-on collisions                          | 4.436 mm                                                     | 0.963E-03                                            | 47.37                                             |
| Rear-ended collisions                        | 4.635 mm                                                     | 0.409E-03                                            | 62.172                                            |

4.5. Descriptive Pictorial Representation:
Here we are plotting graphs of conventional car over solar hybrid car with respect to speed, emission and fuel consumption.

Fig.11. Variation of the fuel consumption (Litres) level against the speed (Km/hr) in a traditional vehicle & hybrid solar powered vehicle
With the increase in fuel consumption (Litres), speed (Km/hr) of conventional vehicles also increases to huge extent but in the case of Hybrid solar powered vehicle, as the fuel consumption increases, the speed become steady after 15 Litres of the fuel consumption as shown above in the fig.11.

![Graph showing emissions vs speed for conventional and hybrid vehicles](image)

**Fig.12. Variation among the excretion/emission discharge level against the speed (Km/hr) in a conventional vehicle and hybrid solar vehicle.**

With the increase in speed (Km/hr) of conventional vehicles, harmful emissions or pollutants produced from the dangerous un-burnt hydrocarbons and other contaminated gases also increases to huge extent but in the case of Hybrid solar powered vehicle, as the speed (Km/hr) increases, the harmful emissions decreases to enormous level and after 40 Km/hr speed, the emissions produced from the Hybrid solar powered vehicle become almost zero as revealed above in fig.12.

### 5. Conclusions

In this novel research work, Design has been created for making solar hybrid car which ultimately results in the widely suitable for maximum fitting of Solar PV panels. Along with that it has a battery unit which has capacity to store maximum electrical energy with high load withdrawing capacity. This research has a valuable future scope as the initial cost is higher during beginning, but once the implementation has been done on large scale than the repair and maintenance cost became very less. Along with that this Hybrid solar powered vehicle follows the emission norms of our country at better grade. This novel design of Hybrid solar powered vehicle also saves fuel along with encouragement in renewable sources of energy. In this way, this research is very environment friendly and economical to fuel cost which eventually results in achieving sustainability: Green environment as well as Industry 4.0 norms as the outcomes revealed that the Hybrid Solar Vehicle are preeminent to conquer most of the harmful emissions and fuel consumption problems in urban city.

### 6. Declaration of conflict of Interest:

The authors declare that they have no conflict of interest with respect to the research, authorship, and/or publication of this article.

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### 8. Ethical approval:

This article does not contain any studies with human participants or animals performed by the author.

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References

[1] Arsie I, Rizzo G, Sorrentino M “A Model for the Optimal Design of a Hybrid Solar Vehicle”, Review of Automotive Engineering, Society of Automotive Engineers of Japan (JSAE), 2008, ISSN 1349-4724, 29-3: 439-447

[2] Pretil Z., Bauer P., Kulcsar B., Rizzo G., Bokor, J., Control Solutions for Hybrid Solar Vehicle Fuel Consumption Minimization In: Proceedings of the 2007 IEEE Intelligent Vehicles Symposium, Istanbul, Turkey, June 13-15, 2007.

[3] Egiziano L., Giustiniani A., Lisi G., Petrone G., Spagnuolo G., Vitelli M., “Experimental characterization of the photovoltaic generator for hybrid solar vehicle”, Proc of 2007 IEEE International Symposium on Industrial Electronics, June 4-7 2007 Vigo (Spain), pp 329-334

[4] Srdjan Lukic M., Mulhall P., Choi G., Naviwala M., Nimmagadda S., and Emadi, A., Usage Pattern Development for Three-Wheel Auto Rickshaw Taxis in India , pp (610-616) in 2007 IEEE

[5] Arsie I, Rizzo G, Sorrentino M, Effect of engine thermal transients on the management of series hybrid solar vehicles, International journal of control engineering practice, (2010) pp1231-1238

[6] Arsie I, Rizzo G, Sorrentino M “Optimal Design and Dynamic Simulation of a Hybrid Solar Vehicle” SAE TRANSACTIONS - Journal of Engines, Vol. 115-3 (2007), pp. 805-811.

[7] Amjad S., Neelakrishnan, S., Rudamooorthy R.; Review of design considerations and technological challenges for successful development and deployment of plug-in hybrid electric vehicles, Renewable and Sustainable Energy Review, 14( 2010) pp 1102-1110

[8] Rizzo, G. (2010), Automotive Applications of Solar Energy, IFAC Symposium Advances in Automotive Control, July 12 - 14 2010, Munich, Germany

[9] Vimal Vas J., Nair V. G., ;Control scheme For Electric Drive Of Solar Powered Vehicles , Indian conference of INDICON(2008) pp75-80 Annual IEEE

[10] Wale J. D. and Pollock,Hybrid C. , stepping motors and drives,l Power Engineering Journal, vol. 15, pp S-1220

[11] Zhang X., Yang J., Bo Sun, Jia Wang; Study on the Policy of New Energy Vehicles In China (2009) IEEE

[12] Shimizu Y., Kamatsu Y., Torii M., Takamuro M.;Solar car Cruising strategy and its supporting system ,Journal of Automobile Engineering Review (1998) pp143-149

[13] Wamborikar Y.S., Sinha A., ;Solar Powered Vehicle, Proceedings of the World Congress on Engineering and Computer Science 2010 Vol. II WCECS 2010, October 20- 22, 2010, San Francisco, USA

[14] Giannouli M., Yianoulis P.; Study on the incorporation of photovoltaic systems as an Auxiliary power source for hybrid and electric vehicles, Journal of Solar Energy 86 (2012) ,pp 441-451

[15] Taha Z., Passarella R., Sah J. M., ; A Review on Energy Management system of Solar Car, Proceedings of the 9th Asia Pacific Industrial Engineering & Management Systems Conference(2008), APIEMS 2008

[16] Dowd’s J., Hines P.; A Review of Results from Plug-in Hybrid Electric Vehicle Impact Studies (2009)

[17] Arsie I, Rizzo G, Sorrentino M; Optimal Design of a Hybrid Solar Vehicle, AVEC06 - 8th Intentional. Symp. On Advanced Vehicle Control - August 20-24, 2006 – Taiwan

[18] Ik Ha J., Suh Koo E., H. Dong Lee, J. Sheok Kim and S. ki Sul; Advanced control strategy of parallel hybrid low emission electric vehicle pp (71-76) IEEE

[19] Karden E., Ploumen S., Fricke B., Miller T.and Snyder K; Energy storage devices for future hybrid electric vehicles, journal of power sources, pp 168(2-11) ,2007

[20] Burke A.F.; Batteries and ultra capacitors for electric, hybrid and fuel cell vehicles, in proceeding of the IEEE and Vol. 95, No. 4, April 2007