Solar powered Hybrid vehicle

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Abstract. In the current scenario, global warming is a threat to the society. One of the major reasons is the release of carbon-di-oxide from an automobile exhaust due to the combustion of fossil fuels which pollutes the environment. One of the optimistic solutions for this problem is to use of hybrid vehicles. Generally, Hybrid vehicle involves a combination of transmission system driven through electrical, solar as well as internal combustion (IC) engine. This work involves hybridization with solar power and conventional power IC engine. Hence it is called a Hybrid Solar Vehicle (HSV). It can be driven both on internal combustion engines as well as on solar energy assisted with electrical motor. In real life applications using solar vehicle produces zero emissions. At present, hybrid electric vehicles are being developed and launched into the market. For long distance travelling its necessary of periodic charging of their batteries, so these vehicles are depends the electrical sources also leads to increase the cost of electricity. These kinds of problems will be solved by using hybrid solar vehicle also HSV supporting to the green environment.

1. Introduction

Hybrid-electric vehicle use IC engines and electric motors, to reduce pollution and achieve better fuel economy. G.J. Offer Et.al [1] investigated performance of battery electric vehicles (BEV) hydrogen fuel cell electric vehicles (FCEV) hydrogen fuel cell plug-in hybrid vehicles (FCHEV) and reported that BEV and FCHEV are relatively insensitive to electricity costs but the FCHEV and FCV are sensitive to hydrogen cost. Saeid Bashash Et.al [2] studied the problem of optimizing the charge pattern of a plug-in hybrid electric vehicle (PHEV) and reported optimizes PHEV charge patterns for both battery longevity and energy cost, for the first time.

Andrew Burke Et.al [3] concluded the power capability of ultra-capacitors and lithium batteries for electric and hybrid vehicle applications and reported for plug-in hybrid and battery electric vehicle applications, the maximum useable power density for a lithium-ion battery can be higher than that corresponding to 95% efficiency. Matthieu Dubarry Et.al [4] investigated using in situ electrochemical inference approach on commercial lithium-ion cells based on composite positive electrode for plug-in
hybrid electric vehicle applications and reported loss of lithium inventory (LLI) may occur as a result of parasitic reactions to form SEI layer on the electrode surfaces.

Jenn-Jiang Hwang et al. [5] studied on the power management system in a fuel cell hybrid vehicle the dynamic performance and power distribution for a fuel cell hybrid electric vehicle (HEV), and reported the power provided by the Li-ion battery is more than that of the fuel cell. S. Kermani et al. [6] concluded Predictive energy management for hybrid vehicle the powertrain operating point in order to minimize the fuel consumption, and reported guarantying bounds on the state of charge error while providing satisfactory fuel consumption. Bor Yann Liaw et al. [7] investigated driving cycle to understand the battery performance in real-life electric hybrid vehicle and reported comprehensive driving cycle analysis could be achieved with unique fuzzy logic Pattern recognition (FL-PR) technique and use this FL-PR technique to analyse duty Cycles and identify useful stress factors to define vehicle usage profile.

Georgios Fontaras et al. [8] studied fuel economy and pollutant emissions measurements of two hybrid electric production vehicles namely Prius II and a Honda Civic and reported that both vehicles Present improved energy efficiency and pollutant emissions compared to conventional cars. The fuel economy benefit of the two HEVs peaked under urban driving conditions where reductions of 60% and 40% were observed, respectively. Karan C. Prajapati et al. [9] investigated about the type of hybrid vehicles and have given us information about the different types of hybrids in their paper and concluded that there are six types of hybrids which include the plug ins and self-charging types. Robert F. Nelson et al. [10] studied the operation of batteries in hybrid electric vehicles. His work reviews the specifications and operational requirements imposed on batteries due to the projected architectures for HEVs.

Anuragh M. Lullhe et al. [11] investigated about the drives used in electric and hybrid electrical vehicles. He stated that the two main types of drives are AC and DC, of which the most widely used, are 3phase Induction motors, Switched reluctance motors, and Brushless DC motors. Teresa Donateo et al. [12] in her paper of intelligent usage of IC engines in hybrid vehicles stated that focuses on different approaches presented in literature on the usage of information about traffic and weather conditions for the optimal energy management of hybrid electric vehicles. Ivan Arsie et al. [13] have given us information on the possibilities hybridizing the currently used Fuel engines with renewable sources of energy. This paper also focusses on the main problems related to the development of these vehicles, with specific attention on photovoltaic panels. Asllan Hajderi et al. [14] have investigated about construction of hybrid vehicles and efficiency of their use in transport, to reduce environmental pollution in urban areas, compared to vehicles with engine. Jinming Liu et al. [15] investigated about the Toyota Hybrid System (THS) is used in Toyota Prius and compared the two major types of hybrids with the split power hybrids.

2. Materials and methods
The detail specifications of the accessories like engine, motor, solar panels, and batteries which are used in this work are discussed below.

2.1 Internal combustion Engine
A four-stroke 150cc engine was assembled in the chassis which produces power of 13.8Bhp and torque of 13.6NM.
2.2 Motor
Motor and its Controller are the two most critical components for HSV. As the selected motor must be able to produce enough torque and power to pull the load. Three types of motors: AC motor, DC motor and Brushless DC motor were taken into consideration. According to calculations and references we concluded by choosing 1.3hp, 48V BLDC motor.

2.3 Motor controller
A motor controller is a component which is used to start and stop the motor also which is used control and varying the speed of the motor drive. The direction of motor rotation also possible to change using this controller during vehicle reverses movement/drive.

2.4 Braking system
Braking system is a key feature in any vehicle. Two types of braking system namely disc brake and drum brake. In this work disc brake is mounted on the chassis for considering the safety precautions.

2.5 Battery
Three types of battery namely lead acid battery, Nickel metal hydride battery and Li-ion battery were examined. Li-ion battery is widely used in the application of hybrid vehicle. In this work Li-ion batteries each of 34 Ah are preferred to store the energy and which is used to drive the motor. Li-ion batteries of 20Amps are used as they will last for about 800 full charge cycles before any replacement required.

2.6 Solar panel
According to the design calculation and torque requirements, 200 watts solar panel has been selected in this work. Four panels of 50 watts capacity each were used. All the materials were effectively utilised to avoid energy losses.

2.7 Solar charge controller
Solar charge controller controls the voltage received from the panel to the battery. It is generally used to convert non-linear energy form into linear energy form. It is used to prevent the short circuiting of the components.

3. Results and Discussion
3.1 Basics of Hybridization
A hybrid vehicle has multiple distinct energy sources which could be separately or simultaneously operated to drive the vehicle. In the solar vehicles, the drive obtained from electric motor through the power stored from the batteries by solar energy.

3.2 Hybrid Solar Vehicle (HSV)
The most commonly adapted hybrid vehicle has sources of a solar power assisted with electric motor and an I.C. engine. In a HSV, the I.C. engine cooperates with an electric motor which has optimal usage of the engine. Especially driving in city traffic involves frequent starts and stops of the vehicle and during idling, the engine consumes more fuel without producing useful work thus it leads to higher fuel consumption, less efficiency and unnecessary emission from the exhaust. The HSV solves those problem and also no exhaust emission from the vehicle. The parallel power train runs on both, combustion engine and electric motor. The primary drive of the vehicle from solar powered and secondary drive by the combustion. These vehicles gain maximum efficiency in city during heavy traffic conditions without producing any emissions which supports to the green environment.
3.3 Charging of Batteries

The power supply to the electric motor comes from batteries. When driving a vehicle on electric motor, the stored energy in the batteries gets used up quickly. Batteries of a HSV are charged by solar power. The solar energy is an efficient way to save more energy. Charging the battery using solar power will be a challenge but can turn out to be a good scope for further development as solar power is freely available.

There are some of the important results inferred from the study.
1. Results were positive for cold rolled steel:

| PROPERTY                   | HOT ROLLED STEEL | COLDROLLED STEEL | ALUMINIUM |
|----------------------------|------------------|------------------|-----------|
| Density                    | 7.77g/cc         | 7.8g/cc          | 2.7g/cc   |
| Bulk modulus               | 140Gpa           | 140Gpa           | 76Gpa     |
| Shear modulus              | 80Gpa            | 70Gpa            | 26Gpa     |
| Elongation in brake        | 15%              | 20%              | 17%       |
| Reduction of area          | 40%              | 50%              | 55%       |

Cold rolled steel has the highest elongation in brake when compared to the other materials. It also has a considerable reduction of area of 50%. It is also commercially available in the market. Considering all these reasons, we used cold rolled steel and fabricated the chassis frame.

- Calculation of the required torque for the selection of engine
  Max. Load needs to be pulled= 600 kg
  Width of the frame = 150cm
  W.K.T Torque = load * perpendicular distance
                = 600 * 150
                = 90000 kg-cm= 9.0Nm.

- So we selected a 150cc engine which has a maximum torque of 13.4 Nm and a maximum output power of 13.8 Bhp. Since the required torque is less than the design torque, the design is safe

- We have selected 48V, 1000 Watts BLDC motor and used in this vehicle. The output torque of the motor with respect to speed and current are plotted and shown in the following figure 2 and 3.
Table 2. Motor output torque with respect to speed

| SPEED (KM/HR) | SPEED (RPM) | TORQUE (NM) |
|---------------|-------------|-------------|
| 10            | 208.97      | 3.58        |
| 20            | 417.94      | 1.79        |
| 30            | 626.91      | 1.19        |
| 40            | 835.88      | 0.897       |

Calculations for obtaining speed and torque:

- Speed in rpm = (speed in km/hr*1000) / (2*pi*radius*60)
- Torque = power / (speed in rpm)

From the above obtained value in the graphs and calculations, a motor of 1000watts-48V was selected. Fig. 2 shows the torque versus speed of the motor which indicates the mechanical characteristics. Selected motor gives the maximum output torque of 14.2 Nm thus more than satisfying than the required torque of 9.0 Nm. The design is safe as the required torque is less than the maximum output torque of the motor. Fig3 depicts current versus speed, known as electrical characteristics which indicate, at the maximum load conditions while increasing the speed of the vehicle the required input current increases. The required input current for the motor, calculated as per design is only 20Amps. The selected motor can produce an output of 14.3Nm when the maximum input current of 31Amps is provided.
4. Conclusion

In this work solar powered hybrid vehicle has been successfully fabricated built in with internal combustion engine. Generally, the electric hybrid vehicles are disadvantageous during long distance travels also required periodic plug in of their batteries. These kinds of problems have been solved using hybrid solar vehicle which gives a car, self-charging potential from the solar panels. The efficiency of the solar panels which is used is 15-20%, but there are various means to increase the efficiency of the panels by changing their silicon materials. The future of energy sector lies solely on alternative energy resources. The cost of HSVs is more than the conventional cars but they are more efficient and cause less exhaust emissions. This challenge now can turn out to be a good scope for further development of a pollution free vehicle.

5. References

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