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Research Article

DESIGN AND ANALYSIS OF COMPOSITE POWER DRIVE CAR

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Abstract

The Electric Solar Vehicle is a single-seated vehicle powered by 750 W BLDC hub motor. Now a day, dealers of natural resources like fuel, coal etc. is facing a hard time to keep pace with the increasing demand. Therefore, to carry out this demand it is quite necessary to make a new exploration of natural resource of energy and power. Therefore, sunlight is now a day's considered to be a source of energy which is implemented in various day to day applications. Solar energy is being used to produce electricity through sunlight. With the help of this technology we aim to make solar energy powered car in our project. The main component to build a solar car is the solar panel. The solar cells collect a portion of the sun's energy and store it into the batteries of the solar car. Before that happens, power trackers convert the energy collected from the solar array to the proper system voltage, so that the batteries and the motor can use it.

After the energy is stored in the batteries, it is available for use by the motor & motor controller to drive the car. We are going to use two set of batteries; one of which will get the electrical energy from the panel to drive the motor and another will be used as auxiliary power source which will provide required power to other electrical devices being used in the vehicle. A microcontroller can be used in this purpose which can switch to the fully recharged battery when it senses that another battery is empty or not providing enough power to drive the motor. Again, we used a complete circuitry to solve the problem of voltage fluctuation due to movement of the sun, earth or cloud etc.

We used a voltage comparator, a relay circuit for and a transistor along with a diode for this purpose. Comparator compares the voltage of solar panel and the battery and then it provides the higher voltage to the transistor to activate the relay which provides the required and stable voltage to the car. However, after all these being proceeded, the motor controller adjusts the amount of energy that flows to the motor to correspond to the throttle. The motor uses that energy to drive the wheels. Preliminarily our objective would be to implement our idea on a basic prototype and afterwards with help of this prototype we can extend our future work on building a real time electric solar powered vehicle.

1.Introduction

ISIE-Electric solar vehicle championship is Asia's largest solar championship. It is a competition to design and fabricate a single seated vehicle which is operated by a DC Motor and power source will be battery as well as solar panel. The purpose of the event is to build up interest towards Mechatronics projects and enhance theoretical as well as practical knowledge .Our aim is to reduce the usage of organic fuel powered vehicle and design environment friendly electric power vehicle to be used in race tracks.

A solar vehicle is primarily powered by direct solar energy. Photovoltaic cells (PVC) are installed on the Vehicle to collect and convert solar energy into electric energy. Made of silicon and alloys of indium, gallium and nitrogen, the

semiconductors absorb light and then release it, producing a flow of electrons that generate electricity which charges the 48V battery connected to it, which runs the 750 Watt Brushless DC Motor to transmit power to drive the vehicle, using some arrangements the motor can run directly by the power generated through solar cells.

As the vehicle is to run for racing on the racing track, so weight of the vehicle should be given proper attention. We are using Seamless Aluminum Pipes and the design is made such that vehicle has proper Power to Weight ratio and is of less weight and has high strength which is the foremost requirement of any solar vehicle.

2. Need for Solar Energy at Present Situation

Earth has limited amount of energy resources which is very soon going to extinct. Fortunately, population models have suggested that the world's population will probably level out at about two to three times the present numbers over the next hundred years. As the population is increasing the demands of people is also increasing. The question is whether the earth's resources are enough to sustain that population at a high standard of living for all. In this the key issue is energy.

Now-a-days, dealers of natural resources like fuel, coal etc. are facing a hard time to keep pace with the increasing demand. At one hand, there are more cars or motor vehicles are dominating the transport medium, on the other hand these cars are being dominated by the fuel. As a result, the limited resources are being quashed by the producers and dealers to satisfy this need which is leading us to an uncertain future with having the scarcity of fuel and minerals. So, present trends in energy consumption, especially oil, cannot be sustained much longer. Also, these are responsible for Global Warming, Environmental Imbalance, Ozone layer depletion etc. which in turn is a big threat to the future human race. Again, in view of the possibility of global warming, these resources are playing a negative role. Therefore, under this circumstance, it is quite necessary to make a new exploration of natural resource of energy and power. But why exploration when the resource is in front of our bear eye. It is effective, less expensive and above all, it is an endless source of energy.

3. Solar Energy

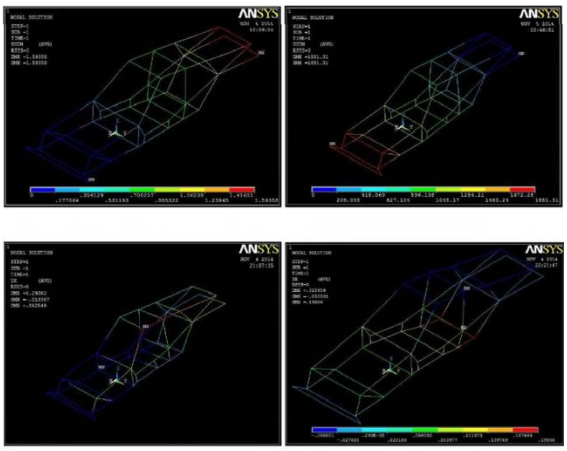
Solar energy is the energy provided by the sun. It is the radiant light and heat from the Sun, harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal electricity, solar architecture and artificial photosynthesis.

Energy is produced in Sun by nuclear fusion during a series of steps called the proton-proton (P P) chain, converting hydrogen to helium. The core is the only part of the Sun that produces an appreciable amount of heat through fusion about 99%. Hydrogen nuclei in Sun's core fuse together to form helium nuclei and release energy, this process is called nuclear fusion. In this state, some 120 million tons of matter--mostly hydrogen are converted into helium on the sun every minute, with some of the mass being converted into energy. The size of the sun determines its temperature and the amount of energy radiated.

Electromagnetic energy from the sun comes to Earth in the form of radiation. The sun radiates energy equally in all directions, and the Earth intercepts and receives part of this energy. The power flux reaching the top of the Earth's atmosphere is about 1400 Watts/m2. This measure simply means that on the average, one square meter

on the side of the Earth facing the sun receives energy from the sun equal to that from fourteen 100-Watt light bulbs every second.

The Earth receives 174petawatt of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected to the space while the rest is absorbed by the clouds, oceans and land masses. The spectrum of solar light at the earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. Yet this amount of energy is very much to utilize for useful work.



4. Design and Calculation

The solar vehicle must be manufactured within INR 80,000.

The vehicle must have a wheelbase of at least 1168.4 mm (46 inches).

The smaller track of the vehicle (front or rear) must be no less than 75% of the larger track.

2 inch suspension travel (1 inch Jounce & 1 Inch Bounce).

Tyres and wheels: using three wheels then there should be two wheels on the front.

Material: use only seamless pipe.

The ground clearance with the driver aboard must be minimum of 50.8 mm (2 inch) of static ground clearance under the vehicle always of the competition.

Impact bumper: Should be an impact bumper on front and rear side of the vehicle.

Jack Points: must be two jack points on the vehicle

Ergonomics: Driver must be able to exit to the side of the vehicle in no more than 5 seconds.

Driver Visibility: must have a minimum field of vision of two hundred degrees (200°) (a minimum one hundred degrees (100°) to either side of the driver).

Push rod: Detachable push rod is mandatory for all the team. Push rod should have the capability push as well as pull the vehicle.

Steering system: The steering wheel must be mechanically connected to the wheels.

The break circuit: It must have hydraulic circuits such that in the case of a leak or failure at any point in the system.

Motor: Teams must use motor of power 1 kW maximum and operating voltage is restricted to maximum 48 Volts at any point of the circuit.

Batteries: Batteries should have maximum of 48V and 50ah all the time of event.

Chassis Material:	Aluminum Alloy 6061-T6
Poisson's Ration:	0.33
Young's Modulus of elasticity:	69000
Roll Cage Mass:	22.285 kg

5. Calculations For Electric Solar Vehicle

Let us consider the following assumption in Electric Solar Vehicle:

Mass of the Vehicle = 130 kg

Speed = 40 kmh^{-1}
Slope % = 0.1
Wheel Diameter = 0.58 m
Battery Weight = 30 kg
Average Speed = 35 kmh^{-1}
Range = 50 km

5.1 Calculation for Angular Velocity Of The Wheel

Considering Linear Velocity = 40 kmh^{-1}
Speed= 40 x (5 / 18) ms^{-1}=11.11 ms^{-1}
Diameter of wheel= 0.58 m
Radius= Diameter / 2
=0.58 / 2 m
=0.29 m
Using the Relation
Linear Velocity:
= Angular Velocity x Radius
Angular Velocity:
= Linear Velocity / Radius
=11.11 / 0.29
From the Relation,= 38.3 $rad.s^{-1}$
Angular Speed= 2 x π x frequency
Frequency= Angular Speed / (2 x π) RPS
=Angular Speed x 60 / (2 x π) RPM
=38.3 x 60 / (2 x 22 / 7) RPM
=365.59 RPM

5.2 Calculation for Peak Torque Required Moving the Vehicle

Using the formula,
Peak Torque
= (Mass of Vehicle + Battery) Acceleration due to gravity x Wheel Radius x Slope%
= (130+30) x 9.8 x 0.29 x 0.1 N-m
= 45.47 N-m
Power Required
= Torque x Angular Velocity (Peak)
= 45.47 x 38.3 Watt
= 1741.5 Watt

5.3 Calculation for Air Resistance

Using the formula,
Air Resistance
= (5 / 100000) x mass of vehicle x $(Average\ Speed)^3$
= (5 / 100000) x 130 x 35^3
= 278.68 Watt

5.4 Calculation for Rolling Resistance

Using formula,
Rolling Resistance
= 0.092 x mass of vehicle x average speed
=0.092 x 130 x 35
=418.6 Watt

5.5 Calculation for Continuous Power Required

Using the Relation,
Power Required (Continuous)
= Air Resistance + Rolling Resistance
= 278.68 + 418.6
= 697.28 Watt

5.6 Calculation for Continuous Speed

Using the Formula,
Continuous Speed
= Average Speed x 60 /(2 x π x Radius of Wheel)
=35 x (5 / 18) x 60 /(2 x π x 0.29)
=320 rpm

5.7 Calculation for Continuous Torque Required

Using the Relation,
Torque Required (Continuous)
=(Air Resistance + Rolling Resistance) x 60 /(2 x π x Continuous Speed)
=(278.68 + 418.6) x 60 / (2 x π x 320)
=20.8 N-m

5.8 Solar Calculation

Motor Specification

Power	750W
Operating Voltage	48V

Battery Specification

Voltage	12V
Capacity	20 AH
Quantity	4

Solar Panel Specification

Power	100 W
Open Circuit Voltage	21.84 V
Short Circuit Current	6.11 A
Voltage at max. power	17.99 V
Current at max. power	5.57 A
Quantity	6

Dimension	1152 x 666 x 34 mm^2

6. Conclusion

The above results discussions as well as mechatronics design for an electric solar vehicle concludes the followings:

A three-wheeled low-cost electric solar vehicle (ESV) for lower income strata of developing countries is feasible and practicable. Our ESV, a single-seated vehicle powered by 750 W BLDC hub motor can be a good choice for Indian market. A multivariate technical group has enriched the design and fabrication of our EVS, for which it stands with higher safety, high performance as well as cost-efficient electric solar vehicle.

The dynamic stability of our ESV has been successfully done through maintaining the CG in the front half of the vehicle which in turn taking care for lateral and rollover stability as well. Our design for wide track, longer wheel base and forward weight distribution system improves lateral stability of the ESV, which also reduces directional stability under braking (as load on the rear gets less) and at the extreme, lifting the rear wheel and tipping the nose to the floor.

During fabrication a special attention was given to reduced cornering stability with acceleration of a tadpole which becomes reduced cornering stability with braking. Uses of Buck Boost Converter in the EVS improve the efficacy of its power system including effective recharging facilities.

Safety and Ergonomics consideration in design as well as in fabrication including drivers' seat design, incorporation of lock nut for motor, suspension, steering, braking and transmission etc. strengthen the acceptability of consumers in Indian roadways.

Application of Automatic Brake Alert in our design strengthens the safety aspects of the ESV which will reduce the severity of any accident. This is our special innovation in this project. The attempt in using a Safe-speed setting (SSS), an electronic device to have a proper control on vehicle propulsion, was also successful for the ESV.

Use of aluminum alloy pipes for light weighted chassis with durable strength, use of Ergonomically designed vehicle interior, running on direct solar power without battery source, use of several advanced electronic devices like kinetic Energy Recovery System, Automatic Brake Alert system, Distance measuring system, Solar panel Heat sensors, Advanced Cooling system etc. have strengthen the vehicle as an advanced ESV in global market. It is an economically viable, low budgeted ESV costing only within INR 80,000. The present eco-friendly ESV, 'RayRacer' can be a choice for future generation consumers.

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