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Design and Performance Analysis of Solar Powered Vehicle- Sun Bicycle

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Abstract: ***Energy is the primary and most universal measure of all kinds of work by human beings and nature. There has been an enormous increase in the global demand for energy in recent years, as a result of industrial development and population growth, Supply of energy is therefore, far less than the actual demand. Due to consumption of energy, demand has increased and the scarcity of the fossil fuels has occurred. The conventional sources of energy are depleting and may be exhausted by the end of this century or beginning of next century, here there is a need to think about renewable energy. Use of fossil fuels for transportation has led to global warming as well as environmental pollution.***
A low cost Solar Energy Assisted Bi-cycles (Sun-bike) is designed and developed with the help of DC motor which is comfortable, easy and great fun to ride. The proposed model is eco-friendly mode of transportation.
Keywords: Solar panels, Solar energy Assisted Bi-cycles, DC Motor.

I. INTRODUCTION

Solar energy, radiant light and heat from the sun, the next wave of future. To harvest the solar energy, the most common way is to use the solar panels. Using the solar panel some amount of energy can be utilized which helps in reducing the human effort. As the fuel is solar energy which is renewable and costless, it makes garden city a green city.

A. Energy Crisis

An energy crisis is any great bottle neck in the supply of energy resources to an economy in popular literature though, it often refers to one of the energy sources used at a certain time and place, particularly those that supply national electricity grids or serve as fuel for vehicles. There has been an enormous increase in the global demand for energy in recent years as a result of industrial development and population growth. Supply of energy is therefore, far less than the actual demand.

1) The energy sources can be divided into three types

a) Primary energy sources: which provide net supply of energy. Ex: Coal, Oil, Uranium.

b) Secondary energy sources: which do not provide net supply of energy. Ex: Intensive agriculture, solar energy, wind energy.

c) Supplementary energy sources: are those whose net energy yield is zero and those requiring highest investments in energy. Ex: Thermal insulation.

The conventional sources of energy are depleting and may be exhausted by the end of this century or beginning of next century. Nuclear energy requires skilled techniques and possess the safety as regards to radioactive waste disposal. Solar energy, bio fuel energy and other non-conventional energy can be utilized in future.

The present energy scenario of the world is as shown below in table 1.1.

Resources	Reserves	Yearly consumption
Petroleum Million tons	720	30
Natural gas Trillion cu ft	22.9	0.88
Coal Billion Tons	246	0.46

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From the table 1.1, it is clear that if the same need continues then there will be energy crisis within few years, hence there is a need to think about renewable energy.

B. Solar energy

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range o ever evolving technologies. Solar radiation along with the secondary solar-powered resources such as wind and wave power, hydro electricity and biomass, in account for the most of the available renewable energy on earth. Only a minuscule fraction of the available solar energy is used.

Solar powered electrical generation relies on heat engines and photovoltaic. Solar energy uses are limited only by human ingenuity. A partial list of solar applications includes space heating and cooling through solar architecture, potable water via distillation and disinfection, day lighting, solar hot water, solar cooking and high temperature process heat for industrial purpose, to harvest the solar energy, the most common way is to use solar panels.

C. History of Solar-Charged Vehicles

Solar charged vehicles evolved soon after the first solar racing vehicles of the Tour de Sol in 1985. The organizers introduced racing classes allowing road-side charging with panels carried by support vehicles, and later with electricity from the grid, provided that the team could prove ownership of enough grid-feeding solar panels anywhere in the world. The production and consumption of solar energy became separated both in place and in time. The rooftop solar panels could work at their full capacity whereas on-board panels have nothing to do once the many of those solar-charging their vehicles in the US are members of a plug-in electric vehicle (PEV) movement which grew out of the opposition to the confiscation and subsequent destruction of EVs such as the General Motors EVI and the Toyota RAV4 EV by large automakers in the early 2000s.

A solar vehicle is an electric vehicle powered by solar panels on the vehicle. Photovoltaic (PV) cells convert the sun's energy directly into electric energy. Solar power may be used to provide all or a part of a vehicle's propulsion, or may be used to provide power for communication, or controls, or other auxiliary functions.

Solar vehicles are not sold as practical day- to- day transportation devices at present, but are primarily demonstration vehicles and engineering exercises, often sponsored by government agencies. However, indirectly solar–charged vehicles are widespread and solar boats are available commercially.

D. Main criterion to opt Sun Bike

1) *Reduce carbon footprint makes garden city a green city:* 50% of all car journeys are of less than 5 KM's duration, which means that there is considerable potential for at least some of those journeys to be made safely and in much healthier way by Sun Bike.
2) *Get there faster:* An electric vehicle may not be faster than a car in terms of absolute speed, but taking into account the time spent in finding a parking spot, putting money in meter, and sitting in traffic jams it all makes sense. An electric bike may not solve everyone's problem but for those who need to commute relatively short distances across urban areas in peak hour it may be worth considering.
3) *Best value for money:* This is an obvious one. Assume we have to commute 15KM to work every day – 105 KM per week. If the fuel-bike gets approximately 4 litres/110KM. Petrol is about Rs.70 per litre. About Rs.280 of petrol per week is used so that would be saving fuel alone. This means it would take 12 to18 months to cover the cost of a Sun bike-if the factor of fuel alone. Parking costs. Tools, insurance, registration, tyres and general wear and tear on a car becomes more compelling. It is a minimum investment with maximum comfort.
4) *Eliminate those parking hassles:* One of the biggest headaches with driving a car is finding a place to park. In city, it becomes quite expensive.
5) *Easy to ride:* Riding sun-bike is fun and also very easy to handle. Peddling gives a great exercise, so it is healthier, better and most comfortable from of transportation.

E. Working of Sun-Bike

It is simple and systematic which consists of a solar panel. When the solar radiation falls on the panel, it absorbs the energy. This energy absorbed is converted and stored in the battery and this battery in turn is connected to a speed controller which will be connected to the motor.

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The energy which is stored in the battery will be used to run the motor and that motor with the help of a chain (free wheel) will be connected to the back wheel which helps to move the cycle with less physical efforts.

F. Objectives

1) Due to consumption of energy, demand has increased and the scarcity of the fossil fuels has occurred. As all these fuels are non renewable source of energy which exhaust completely and only solar energy will be the major option.

2) Use of fossil fuels for transportation has led to global warming as well as environmental pollution. Hence it is necessary to use eco-friendly transportation modes as far as possible. Bi-cycles are such wonderful options for short distance travel.

3) Considering the above factors, it is proposed to develop low cost Solar Energy Assisted Bi-cycles.

G. Design of Battery

In order to run a motor of 60W for one hour 60WH of energy is required and if 3 day backup is considered, then

60*3 = 180WH of energy is required.

The energy drawn by the motor is at 8V. So

180WH/8V = 22.5AH

Considering some losses involved 24 AH battery is chosen. Figure 2 shows pictorial representation of battery.

H. Design of Solar Panel

It is observed that if solar panel is charged for 3 hours, and if 10W panel is considered only 30WH/day is achieved. Hence it is sufficient and better to opt for 20W solar panel.

The battery is charged at 24V, and from 20W panel only 12V is generated which is not sufficient. So two 10W panel are connected in series to generate 24V. Figure 3 shows pictorial representation of Solar Panel.

I. Design of Vehicle

Performance of vehicle depends on the design for the capacity of the components. Depending on the load and resistance the capacity of the motor, solar panel and battery can be calculated.

Equations of mechanics are been considered to calculate the power required to ride a bicycle, the capacity of a motor required to satisfy the power requirement can be designed. Considering the motor capacity the solar panel and the battery will be designed to

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satisfy the power requirement and effective working of the motor.

J. Power Requirement neglecting the external resistant forces

In order to calculate the power required to drive from the initial velocity zero to 10 km/hr in 10 seconds neglecting all other external forces and also all the resisting forces, acting over the body. Consider total mass as 80 Kg.

The following equations are obtained [1].

Power = Force X Velocity [2.1]

Force = mass X acceleration [2.2]

V = U+at

When the body moves from rest, then initial velocity is zero (u = 0)

$a = V/t = 2.77/10 = 0.277\ m/s^2$

Substituting in equation [2.2], we get

Force = 80X0.277

= 22.16N

From equation [2.1],

Power = 22.16X2.77

= 61.38Watts.

K. Power Requirement considering the frictional forces

To calculate the power required to drive the vehicle by considering all the external forces and resistances acting over the body, as per the equations given in the mechanics. The following equations were considered for the calculation [2].

Let us consider mass as 80Kg, inclination angle (a) = 30^0 and co-efficient of friction = 1.3.

P = [w Sin(a+b)]/Cos b……. [2.3]

b = (1/tan) d

Substituting the above values in [2.4],

b = 52.43

Substituting the above values in [2.3],

P = [80 Sin(30+52.43)] / Cos 52.43

P = 130 Watts

L. Power Requirement considering all the resisting forces

To calculate the various resisting forces acting over the vehicle[3], certain methods are given followed by certain equations, which can be used to calculate the power to overcome all kinds of resisting forces. Considering mass as 80 Kg, Velocity is 10 m/s and other constant values as given.

The force resisting the motion of the bicycle F_{total} consists of the sum of rolling friction f_{roll}, aerodynamic drag F_{wind}, the force needed to accelarate F_{accel}, the upward slope resistance F_{slope}, the bearing friction resistance.

$F_{total} = (F_{roll} + F_{slope} + F_{accel} + F_{wind})$… [2.5]

The individual retarding forces are described as follows.

F_{roll} = cr*m*g

= 0.015*80*9.81 = 11.772

F_{slope} = s* m

= 0.5*80 = 40

F_{accel} = a* m

= 0.06*80 = 4.8

$F_{wind} = r^* cw^* A^* v_{wind}^2/2$

=1.22521*0.015*00.69*0.554^2/2 = $2.1998*10^{-3}$

$F_{total}=(11.772 + 40 + 4.8 + 2.19989*10^{-3}) = 56.57$

The power required to overcome the total drag is:

$P = F_{total}$ v = 56.57*2.77

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P = 156.71 Watts

II. PERFORMANCE ANALYSIS

The testing has been done on the sun-bike during full load condition to check the performance of the motor, battery and solar panel.

A. It is observed that during load condition the current (ampere) output from the battery is 4A.

B. During full load condition the current drawn by the motor is 8A.

C. Sun-bike is charged for five hours in a sunshine day, and it is observed that in a full load condition the motor could run for one hour 20 minutes.

III. CONCLUSION

Due to the use of fossil fuels for transportation, leads to global warming as well as environmental pollution. Hence using of eco-friendly transportation modes is necessary. A low cost solar energy assisted bi-cycle called Sun-Bike is designed and developed which is comfortable, easy and great fun to ride.

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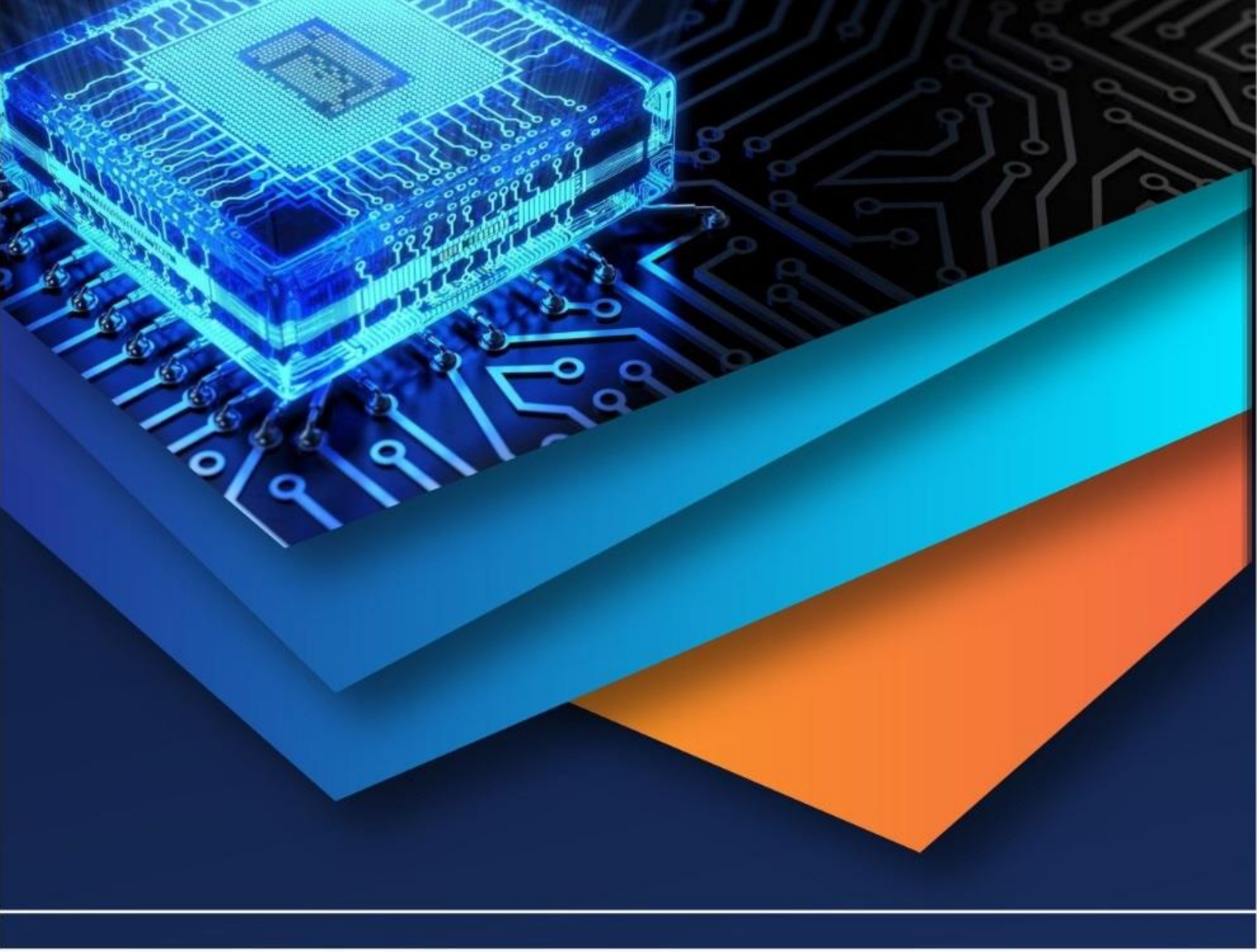

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