

Design and Development Solar Assisted Electric Bicycle

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ABSTRACT: With increase in population the demand for two wheelers and moped vehicles has also increased. This has further led to spike in the pollution levels and also increased the cost of Fuels. Solar e-bicycle's is to drive with renewable energy as the fuel. As renewable energy is free, the operating cost of the vehicle is zero. Also, the vehicle has zero emission rates for harmful gases. It basically operated on three modes: Solar mode, Wall plug-in charge and manual pedal mechanism. In solar mode the electricity is stored in battery with the help of photovoltaic polycrystalline solar panels. The rider can also opt to normal pedal system in absence of electricity. The operation of Solar bicycle is smooth and silent.

KEYWORDS: Sunlight, renewable, energy, chain sprocket mechanism, BLDC motor, Solar e-vehicle etc.

I. INTRODUCTION

By 2040, the Indian government plans to replace all its petrol-diesel based vehicles with electric vehicles. But there is a lack of innovation and development in this field. Electric bikes are being bought to the market but most of the customers are not satisfied with those bikes. The reasons being:

- 1) The selling price is too high.
- 2) The cells of the battery have less warranty and if they get damaged the new ones are costly.
- 3) Sometimes the battery discharges very quickly.
- 4) The chassis of the e-bike is very weak.
- 5) Average given by the bike is less.

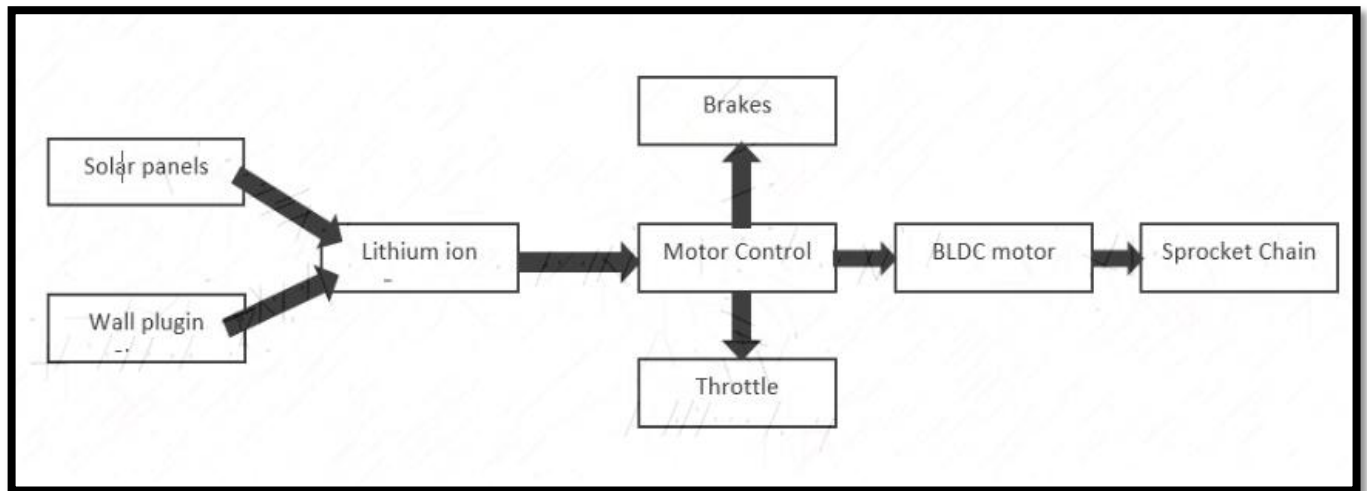
These factors mentioned above make the e-bike less dependable. Can something be done about it? Here, in this research I plan on creating a e-vehicle which will not only be economical but also lessen the drawbacks mentioned above. Around 173,000 terawatts solar energy strikes the earth's surface every moment. This energy is more than enough to fulfill the needs of all human beings and has a great application in the field of automobile. Here I plan to make an e-bicycle which will run due to three modes:

- i) Wall plugin charge
- ii) With the help of Solar energy
- iii) Pedal system

This bicycle will completely work on renewable sources. Thus, zero emissions of any harmful substances.

II. METHODOLOGY OF SOLAR E-BICYCLE

Components of Solar e-bicycle are Battery, Solar panels, Motor, Throttle, Digital Odometer and Speedometer. The arrangement is shown in the below diagram



The solar e-bicycle will operate in three different modes: -

- a. The Solar e-bike will have solar panels mounted on it. These panels will convert the solar energy and charge the battery.
- b. Whenever sufficient sunlight isn't available the user can opt to charge to with the help of wall plugin charge.
- c. In rare cases, whenever both sources of charging the battery are absent the user can choose to manually pedal to drive the vehicle.

III. DESIGN CALCULATIONS:

Maximum weight that the bicycle can carry:

Assume that the rider is moving in a straight line at constant speed having four sources of resistance to overcome:

1. Resistance due to air:
 - This resistance is caused by the flow of air in the opposite direction of the rider while driving.
 - It is given by: Force generated by air resistance = $0.5 \times \text{Coefficient of drag}(C_d) [\text{usually } 0.9 \text{ for bicycle}] \times \text{Frontal area of bicycle} \times \text{Density of Air} (\rho) \times (\text{Velocity of air})^2$.
2. Resistance due to Rolling:
 - This resistance is caused by the tires rolling on the ground.
 - It is given by: Force generated by rolling resistance = $\text{Coefficient of rolling resistance} (C_r) \times \text{Weight that bicycle can carry} (w)$
 - But when the surface is inclined, then the force is given by: Force generated by rolling resistance = $\text{Coefficient of rolling resistance} (C_r) \times \text{Weight that bicycle can carry} (w) \times \cos \theta$.
3. Resistance due to gravity:
 - Only calculated when the surface is inclined; force is given by: Force generated by rolling resistance = $\text{Weight that bicycle can carry} (w) \times \sin \theta$
4. Friction in the chain, bearings etc.
 - This is usually considered to be about 5 % of the applied power
 - This friction is given by: $0.05 \times F_{\text{applied}}$, where $F_{\text{applied}} = (\text{Resistance due to gravity} + \text{Resistance due to rolling resistance} + \text{Resistance due to air} + \text{Resistance due to chains and bearing})$
5. Power applied:
 - Power applied to move the bicycle is given by: $P_{\text{applied}} = F_{\text{applied}} \times \text{velocity of air } V$.

But in this scenario, the maximum weight is that can be applied is already given by vehicle manufacturers (Hercules MTB turbo-drive). The allowable weight is 100kg.

IV. SELECTION OF THE COMPONENTS:

A. Motor: Brushless D.C. motor is selected due to its smooth, noiseless and efficient operation. Since maximum permissible load is equal to 100 kg, the Normal reaction acting on each tire is equal to $N = 50 \times 9.81$ Newton each.

a. Static Friction force acting on the tire (F_1):

- $F_1 = \mu \times N$ (where μ = coefficient of static friction = lies between 0.1-0.9 on concrete/asphalt roads = 0.26 average value assumed and N is reaction on each tire)
- $F_1 = 0.26 \times 490.5$
- $F_1 = 127.53$ N

b. Dynamic Friction force acting on the tire:

- $F_2 = C_{df}$ (coefficient of dynamic friction) $\times N$
- $F_2 = 0.004 \times 490.5$
- $F_2 = 1.22$ N

c. Speed calculations:

The tires of the selected cycle (Hercules MTB turbo-drive) have a diameter = 0.533m

- $w = v \div r$,
- $w = (20 \times 1000) \div (0.2665 \times 3600)$
- $w = 20.84$ rad/sec
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- But, $w = (2 \times \pi \times N) \div 60$
- $N = (60 \times \omega) \div (2\pi)$
- $N = (60 \times 20.84) \div (2\pi)$
- $N = 198.98$ rpm

d. Torque produced (T):

- $T = (F_1 + F_2) \times$ radius of the tire
- $T = 128.74\text{N} \times 0.2665$ m
- $T = 34.31$ N

e. Power calculations:

- $P = (2 \pi N T) \div 60$
- $P = (2 \pi \times 198.98 \times 34.31) \div 60$
- $P = 652.56$ W

Therefore, a motor with power of 652.56 with peak wattage 700W is selected.

For controlling motor Arduino Board is chosen with Technical Specifications:

- Microcontroller ATmega328
- Operating Voltage 5V
- Input Voltage 7-9V
- Input Voltage (limits) 6-20V

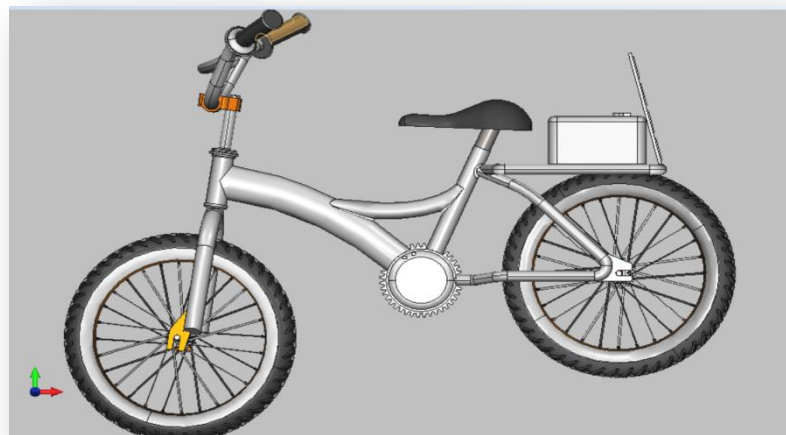
B. Battery specification:

- Power (P) = Voltage(V) \times Current (I)
- $P = V \times I$
- $652.26 = 24 \times I$
- $I = 27.1775$ Ah

- Battery selection: Now, there are two types of batteries commonly used: Lead Acid and Lithium ion batteries. Due to durability, warranty and Safety factors lithium ion battery is selected. That select 2 batteries of 12V, 12.5Ah around 300 watts. We connect these batteries in series to achieve a voltage of 24V as required by the motor.
- C. Solar panels:
1. The basic function of solar panel as we all know is to convert the solar energy and store in the battery.
 2. A solar panel of 100-watt capacity is selected.
 3. To charge the battery completely, it needs $300/100=3$ hours are required. The DC voltage booster keeps the voltage optimum for the battery to get charged even while the voltage falls below threshold in diffused sunlight.

V. ASSEMBLY AND WORKING OF SOLAR E-BICYCLE

- 1) Firstly, the solar panels are mounted on the backside of the drives seat beneath which the battery is mounted. The battery is tailored in a tactic that the harmony of the load isn't disrupted. The fabrication is carried out keeping in mind the maximum load that the motor will be able to withstand. The B.L.D.C. motor is connected to rear wheel through chain drive. All the fabricated parts are then assembled. The throttle is fitted on the handle which is powered by the battery. The throttle then gets powered through the battery and sends signal to the B.L.D.C. motor to run/stop itself. The motor controller installs control the speed of the vehicle and the braking system.



- 2) Mechanism of the system starts with the charging the battery either through Sunlight or wall plugin charging system. After the battery is charged. Then current flow to the motor and then the motor energizes through the current, the stator field coil gets magnetized and induces the rotor shaft to rotate in the counter clockwise direction. At the end of the motor shaft relevant conditions are made for the seating of sprocket assembly. Then, through the sprocket chain mechanism the vehicle moves forward.

VI. CONCLUSION

- 1) A Solar e-bike with an average speed of 25kmph and average distance travelled of 40 km is designed. It is cost effective. The entire model takes around Rupees 21,000 for its creation which is very cheaper than the e-bikes available in the market today. A digital odometer and speedometer is used for measuring the maximum distance and maximum speed at which this bike can be driven.

- 2) It can be operated throughout the year free of cost. The most important feature of this bike is that it does not consume valuable fossil fuels thereby saving a lot on fuel expenses. It is eco-friendly pollution free, as it does not have any emissions.
- 3) Moreover, it is noiseless and can be recharged with the AC adapter in case of emergency and cloudy weather.
- 4) It also can be modified and made suitable for aged, handicap people.

VII. FUTURE SCOPE

- a. Small wind turbines can be added to the Solar e-bicycle in order to generate electricity by air while driving.
- b. This same “mechanism” can be used for heavy duty vehicles.
- c. While pedaling manually an effective electricity generating unit can be attached. In order to generate and store electricity with the help of pedals.
- d. Solar e-bike can be modified further and make it to use for physically disabled people. Even Solar e-bike can be digitized by advance sensors, etc. Gear variation system can also be implemented to increase torque and control speed.

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