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Design and Fabrication of Solar Hybrid Bicycle

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Abstract : As everyone is aware, the cost of fuel, particularly gasoline, is progressively growing every day. Again, vehicle-related pollution in major cities and urban regions is constantly rising. An effort is being made to look for more alternate sources of energy for the cars in order to solve these issues. Again, purchasing vehicles (such as mopeds, scooters, or motorbikes) for every social class is not financially feasible. With this in mind, efforts were made to find a means to both help these economically disadvantaged people and address environmental degradation. Solar photovoltaic (PV) panels offer a practical and economical approach to generate electricity. Utilizing solar energy, PV panels almost entirely free electricity in some nations where electricity is still highly expensive. Transportation, which emits significant amounts of smoke and carbon, is a significant source of pollution in modern cities. The aim of this paper is to develop a hybrid bicycle (electric and manual) powered by solar energy. The aim of this research paper is to fabricate and test a solar hybrid bicycle. The created solar-assisted bicycle would be powered by solar energy and will have a BLDC motor for propulsion. The BLDC motor is powered by the battery, which is recharged by the solar panels positioned on the backside of the cycle. The solar panel will recharge the battery when the bike is stationary. The Hybrid Solar Bike System is a system that combines three distinct methods of charging Lithium-ion batteries: a 12V wall adapter and solar energy. This system powers the BLDC motor that propels a bike.

IndexTerms **- Solar energy, BDC Motor, Lithium-ion battery.**

I. INTRODUCTION

The fuel prices are increasing around the world day by day. The internal combustion engine vehicles contribute to pollution around the globe. Hence there is a need to develop a vehicle that will run on renewable energy source. Solar bicycle is one such solution which will utilize the solar energy to charge the battery which will power the motor. The solar assisted bicycle is cheap and is affordable to everyone. It can be used for short distance rides by college students, office persons and in city as well. The solar assisted bicycle can be charged by pedalling as well with the help of dynamo. Whenever the bicycle is unused during the day, it will be charged with the help of a solar panel. Thus, the solar bicycle can be a good alternative to fuel powered vehicles.

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II. LITERATURE REVIEW

[1] Kartik S Mishra, Shubham V Gadhawe, studied that due to increasing prices of fuel worldwide it is a necessity to find an alternative source of energy for transportation. A solar bicycle is an alternative mode of transportation that harnesses the energy from the sun and provides voltage to the battery which will power the cycle. Owing to India's exposure to the sunlight throughout the year, the concept of Solar bicycle is very friendly. Solar hybrid bicycle combines the use of Solar energy as well the dynamo that runs with the help of pedals which would charge the battery. They used hub motor to power the bicycle and lead acid battery as the powerhouse. Two solar panels of 50W and 12V were used. The cycle was designed for a speed of 15 kmph. The charging time with the help of Solar panels was found to be 3.6 hours whereas it was 2 hours with the help of the adapter.

[2] T. Suresh, T.D. Subha: The conventional bicycles need to be pedalled to be moved whereas motorcycles use fuel as its crude power. The electric bicycle has a capacity of maximum 1 hour. To counter these discrepancies, the idea of Solar bicycle came into picture. The vision was to charge the bicycle whenever not in use with the help of renewable solar energy. The solar energy would be consumed by a solar panel and would be sent to power a high torque motor. The controller in the bicycle controls the flow of electricity from battery to the motor thus making the operation efficient. A brushed DC motor was used. Lead acid batteries were chosen to power the bicycle. The cycle achieved a speed of 15 kmph on a plain road. On the surfaces having inclination of 15 degrees and 30 degrees the speed obtained was 7 kmph and 3 kmph respectively. The battery discharged in 50 mins. It took 7.2 hours to fully charge the battery with the help of solar energy and 2.4 hours with the adapter.

[3] Lina Al-Chaarawi, Merna Hawary: They fabricated a solar hybrid bicycle with sophisticated power control and monitoring system. One of the convenient ways to produce electricity is with the help of Solar energy. They also prove to be cost effective. To counter the pollution by vehicles, a solar bicycle is proposed. The battery would be charged with the help of solar panels mounted on the back stand of the bicycle. The cycle can be operated in two modes- manual and with the help of motor. The bicycle's battery has a 220V AC charger which would be useful to charge the battery during night-time and inconvenient weather conditions. They used a hub motor of 250W 36V and lithium-ion batteries of 36V 10.4 Ah. Two solar panels of 50W 18V were used to consume the solar energy. The average speed of the bicycle is 15.5 kmph.

[4] Bhavin Shah, Mehul Manubarwala: In this paper, discussions about solar smart bicycle and its status in the world is discussed. The rapid increase in fuel prices has made the role of renewable energy significant. The effects of smoke released from the vehicles are deadly on humans. Solar energy is used to charge the batteries of the bicycle. They have used BLDC motor to convert electrical energy into rotational energy to propel the bicycle. The solar panels of 20W 24V were used. The cycle had an average speed of 15 kmph. The time required to charge the batteries with the help of Solar energy was 9.2 hours and 2 hours 15 minutes with the help of adapter.

[5]Rajendra Beedu: This paper's discussion covers the design, assembly and performance evaluation of solar assisted tricycles. The tricycle is fabricated by modifying a simple geared bicycle. The paper also highlights the advantages of dual mode of charging and economic feasibility of the tricycle. A brushless DC motor of 300W 24 V was used. Two Lithium-ion batteries of 12 V 12 A were chosen to power the motor. Solar panels of 20W and 24 V were used. The top speed of the tricycle was found to be 9 kmph on a plain road. The range of the bicycle was 9 kilometres. The charging time with the help of solar energy was found to be 7.2 hours and 2.4 hours with the adapter.

[6] K. Ramash Kumar, T. S. Anandhi: This paper aims to investigate the design computation and prototype model implementation of a modified mechanical structure electric bike. The paper proposes an estimated design and model implementation of electric bike with smallest number of parts, lowest expense and lightest weight possible. Major parts of the bike are- a 500W 48V BLDC motor, 48V 12 A Lithium-ion battery. The weight of the bike was 20 kgs and achieved a top speed of 25 kmph.

[7] Saurabh Chauhan: This paper aims at simplifying the calculations required to decide the capacity of the motor that should be used to drive a vehicle of specifications. All electric vehicles run on DC motors. However, the motors are available with lot of options in size, speed and method of operation. The torque drives the wheels and set the vehicle in motion and this paper presents one such method of calculating the torque.th

[8] Pratap Kumar Koppolu, Krishnan CMC: This paper presents a method to make a hybrid electric bicycle by modifying the existing conventional bicycle keeping the ability to pedal. The cycle consists of a battery, motor drive which comprises of DC-DC Converter for the motor as well as regenerative braking. The bicycle consisted of a brushed DC motor of 250W 24V and Lithium-ion battery of 24V 13 Ah. The range of the bicycle is 28 kilometres with 23 kmph top speed.

[9] Hardik Keshan, Jesse Thonburg: This paper compares different aspects like varying efficiencies, charging characteristics, life cycles and costs between the lead acid battery and the lithium-ion battery. When considering the length of operational life and the charge/discharge cycles, lithium-ion batteries are more economical than lead acid batteries. Lithium-ion batteries are characterized by superior efficiency, longer lifespan, quicker charging capabilities, and lower cost per unit of energy over the course of their lifetime.

[10] Prof. Ravikant K. Nanwatkar, Abhijit Khairnar: The paper focuses on making the cheapest rate electric bicycle. We are dependent on fossil fuels to produce electricity, transportation, etc. The main disadvantage of fossil fuels is that are non-eco-friendly and exhaustible. To counter these problems, we must look at non-conventional energy sources. Many cities have tried to promote cycling. Electric bicycles use energy from the battery which is fed by the solar cells. The pollution issue is swelling in the metro cities rapidly therefore it is necessary to modify the conventional bicycles into electric ones. They used 3 Lithium-Ion batteries in series and 8 in parallel for their bicycle with specifications of 12V 20Ah. The motor was of brushless DC motor types having a power rating of 350W and operating voltage of 36V. Solar panels of 75W were chosen. The solar ran for 2 hours and had a range of 25 kilometers.

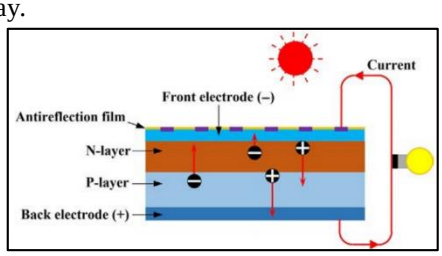
[11] Geetam Richhariyaa , Anil Kumar: This chapter gives in-depth knowledge about the solar cell technologies and their use in the upcoming improved industrialization. The chapter covers the working principle of the solar cell. Along with that it covers different types of solar cells in depth.

III. METHODOLOGY

The process of making the solar hybrid bicycle started with research of previous literatures. From the literature, the calculations and required components were identified. Components were affixed to the bicycle and frame for solar panel was fabricated. The cycle was tested in varying conditions for top speed and its range. Along with that charging times with Solar panels and adapter was also found out.

A) Solar Panels

A solar cell is a semiconductor diode which is designed to obtain and use photonic energy conveyed by radiant light from the sun to generate electrical energy in a efficient way.



The key physics of a solar cell is demonstrated above.

Flexible solar panels of 40W 12V were chosen. They were connected in series to get the required voltage of 24V. The electricity produced by these would be fed to the battery through a solar charge controller.

Flexible Solar Panels

B) BDC Motor

A brushed DC electric motor is a type of motor that uses direct current to create movement. They were the first type of electric motor to be used commercially to power machines and were used in buildings for over 100 years. Brushed DC motors can change speed by adjusting the voltage or magnetic field strength. Depending on how the motor is connected to the power supply, it can maintain a steady speed or adjust its speed based on how much force it's working against. To control the speed, you can adjust the battery or power supply, use resistors, or electronic controls. You can change the direction of the motor by reversing the connections of the field or armature, but not at the same time. This is typically done with special contactors. A *permanent magnet DC motor* has a quadratic relationship between its speed and torque, where the torque is highest when the motor is not moving, and the speed increases as the load decreases.

BDC Motor

C). Battery

Lithium-ion batteries have high efficiency, long lifetime and faster charging capabilities and lower incremental cost for the energy supplied throughout their lifetime.

Lithium Ion Battery

D) Motor Controller

This solar hybrid bike system includes solar panels, a battery and a brushless dc motor, so a controller is needed to regulate each of the various bike system components. This controller has a variety of uses, including driving and controlling Brushless DC motors as well as protecting against low voltage and high current. Different signals, such as current detection signals, motor speed control signals, and capacity detection systems, were transferred to pins on the controller to drive and regulate brushless dc motors.

Motor Controller

MOTOR CALCULATIONS

Considering Total weight of bicycle = 80 kgs
Total Tractive Effort = Rolling resistance + Grade Resistance + Acceleration force

Rolling resistance = Weight * Crr
= 80 * 9.81 * 0.015
= 11.77 N

Grade Resistance = Weight * sinα
= 80 * 9.81 * sin (2)
= 27.39N

Acceleration Force = $\frac{Weight*Vmax}{g*time\ required}$
= $\frac{80*9.81*5}{9.812*20}$ = 20N

Total Tractive Effort = Rolling resistance + Grade resistance + Acceleration Force
= 11.77 + 27.39 + 20
= 59.16 N

Torque = TTE * r * Fr
= 59.16 * 0.285 * 1.15
= 19.38 Nm

Angular velocity (ω) = $\frac{v}{r}$ = $\frac{5}{0.285}$ = 17.54 r/s

Power requirement = Torque * ω = 17.54 * 19.38
= 340W

Power is expressed in terms of torque and speed. The solar panel is used as an accessory strength to ride the bicycle. A motor with a power of 350W is chosen.

Also,
Power = Voltage * Current
350 = 24 * I
I = 14.58 Amps
Therefore, selecting a battery of 24V 15A.
The power adapter has a rating of 12V 12A.
P = V*I
= 12 * 12
= 144W
Selecting a solar panel of 40W, 24V
Time required for charging with Adapter =
Battery power/ Adapter power= 336/144 = 2.3 Hours

Time required for charging with solar panel =
Battery Power/ Solar Panel = 336/ 40 = 8.4 Hours

Fabricated Solar Hybrid Bicycle

IV. FABRICATION PROCESS

The production process involves attaching various components to the bicycle's frame. The motor is fixed to the rear wheel axle. The battery casing holds the 24 V, 14Ah Li batteries that is affixed to the frame. The wires connect the battery to the motor, providing power, and also include speed control wiring. Two solar panels are mounted on the rear side of the bicycle. A solar charge controller is positioned on the panel frame, with appropriate wiring done to allow for charging by either solar power or electrical charging. The throttle attached to the handlebars regulates the motor's power supply and can stop it. The traditional friction brake on the cycle also stops both the motor and the cycle simultaneously.

V. RESULTS

The cycle was kept in bright sunlight to charge. It took 8.6 hours to fully charge the battery. With the help of the Charger, it took 2.5 hours to fully charge the battery. Testing was done on different road conditions that would replicate daily conditions for the usage of the cycle. A top speed of 20 kmph was achieved.

VI. CONCLUSION

The fabrication of solar hybrid bicycle was successfully completed. The fabricated solar hybrid bicycle is a good alternative to conventional transportation for short distances. Our bicycle can achieve a top speed of 20 kmph. The battery can be charged in two modes- Solar energy and Wall charging. Solar energy charges the battery in 8.6 hours whereas Charger takes 2.5 hours to fully charge the battery.

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