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Performance Analysis of Solar Powered E-Bicycle

Anand V. Shivashimpi[1], Bhagyashri S. Ambalgi[2] , Mansi J. Zambare[3], Suprabodh A Umare[4], Pravin S Phutane[5]

Assistant Professor, Dept. of EE Dr. D Y Patil Institute of engineering Ambi, Pune, Maharashtra, India[1&5]

UG Student ,Dept. of EE, Dr. D Y Patil Institute of engineering Ambi, Pune, Maharashtra, India[2-4]

ABSTRACT:We all know that the fuel price and pollution due to general vehicles in metro cities and urban areas is increasing day by day. To overcome these problems, alternatives methods are being developed. The solar assisted bicycle developed is driven by BLDC motor fitted in front axle and is operated by solar energy. The solar panels placed on the bicycle will charge the battery which further drives the BLDC hub motor. When the bicycle is not in use, the batteries get charged using the solar power; also, batteries can also be charged using a wall charger. This model is being designed in order to overcome few problems associated with previous models. Few problems from previous models are rectified in this prototype and required tests are carried out.

KEYWORDS: Solar Panels, Bicycle, Hub Motor, Motor controller, Batteries.

I.INTRODUCTION

Solar bicycle is designed to meet the present challenges of conventional bikes andalso to reduce the pollution caused by conventional bikes.Again, it is also not affordable to purchase vehicles (mopeds, scooters or motorcycles) for all the class of society. Keeping this in mind, a search for some way to cater these economically poor people as well as to provide a solution for the environmental pollution was in progress. The solar assisted bicycle developed is driven by DC motor fitted in front or rear axle housing & operated by solar energy. The solar panels mounted on the carriage will charge the battery & which in turn drive the hub motor. When the bicycle is idle, the solar panel will charge the battery. This arrangement will replace the petrol engine, the gear box & the fuel tank in case of a two wheeler or a chain sprocket, chain & gear shifting arrangement of a conventional bicycle being used by most common man.As a part of dissertation work, the solar assisted bicycle is fitted with a dc hub motor on front axle of a bicycle with power rating of 250W and with a travelling speed of around 25-30 kmph. It is provided with a pair of lead acid batteries of 35 Ah each, a photovoltaic solar panel with capacity of 20 watt, a voltage regulator of 24v 10 Amp, accelerator and motor controller of 24v 25Amp. There is also a provision for charging of the battery with 220-240V, AC wall outlet supply, in case of poor solar supply due to cloudy weather.The solar electric bicycle may notcost substantially more energy to drive the solar electric bicycle, when not powered, than abnormal bicycle. When there is no sunlight or the batteries are empty the bicycle should stillbe running. E-bikes need large and heavy batteries to allow riding long distances, because the n battery is charged only once at home. The solar bicycle approach is different. The PV panelshave enough power and give the bicycle an infinite range. The battery is small, and saves weight. Without sun however, the battery can be fast charged. The battery will be charged while the bicycle is running.

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II.METHODOLOGY

The solar assisted bicycle consist of following components (Fig.1) - hub motor, solar panel, voltage regulator, lead acid battery, motor controller, accelerator, bicycle.

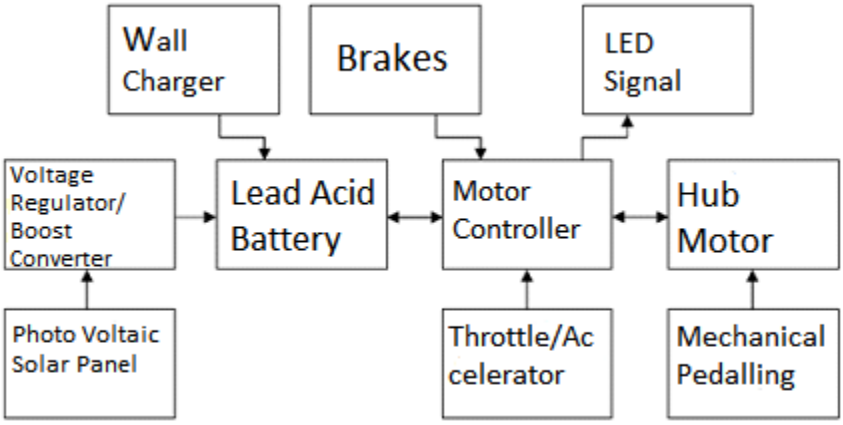

Fig 1- Block Diagram of the Bicycle.

A. Hub Motor

The hub motor is a conventional Dc motor. The rotor is outside the stator with the permanent magnets mounted on inside. The stator is mounted and fixed onto the axle and the hub will be made to rotate by alternating currents supplied through batteries. Hub motor generates high torque at low speed, which is highly efficient and which doesn't need sprockets, brackets and drive chains. This means they are very reliable and have a long life. The main characteristic of Brushless DC Machines is that they may be controlled to give wide constant power speed ranges.

Type of Motor	Hub Motor
Design of Motor	BLDC Motor
Power Rating	250 W
Rated Voltage	24 V
Speed	300 (rpm)
Torque	12 N-m

Table 1 – Specification of Hub Motor

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B. Solar Cells/ Panels

As the title suggests the bicycle is operated by solar energy. The lead acid battery is charged with solar energy with the help of a solar cell. Solar cells convert the energy of sunlight directly into electricity through the use of the photovoltaic effect. The photovoltaic effect involves the creation of a voltage into an electro-magnetic radiation. The photoelectric and photovoltaic effects are related to sunlight, but are different in that electrons are ejected from a material's surface upon exposure to radiation of sufficient energy in photoelectric, and generated electrons are transferred to different bands of valence to conduction within the material, resulting in the build-up of voltage between two electrodes in photovoltaic.Solar cells are electrically connected and fabricated as a module with a sheet of glass on top to allow light to pass and protect the semiconductor from the weather. To obtain a desired peak DC voltage we will add solar cells in series, and to obtain a desired peak current, the solar cells are put in parallel position (Fig.2).

Charging Current (Amp)	**2**
Open Circuit Voltage (V)	21.6
Max Power Voltage (V)	17
Short Circuit Current	1.316
Lifespan	25 years

Table 2 – Specification of Solar Cell / Panel

C. Lead Acid Battery

Lead acid batteries are one of the most popular types of battery in electronics. Although slightly lower in energy density than lithium metal, lead acid is safe, provided certain precautions are met when charging and discharging. This have a many advantages over other conventional types of batteries, the lead acid battery is the optimum choice for a solar assisted bicycle. Current supplied from battery indicates the flow of energy from the battery and is measured in amperes . The higher the current flow faster the battery will discharge. A battery is rated in ampere-hours (abbreviated Ah) and this is called the battery capacity. This project revolves around supplying and utilizing energy within a high voltage battery. It demands for a battery with longer running hours, lighter weight with respect to its high output voltage and higher energy density. Among all the existing rechargeable battery systems, the lead acid cell technology is the most efficient and practical choice for the desired application. The battery chosen for this project was a high capacity lead acid battery pack designed specifically for vehicles. Plastic casing is providedto house the internal components of the battery.

Type of Battery	**Sealed Lead Acid**
Number of Batteries	Two Batteries connected in series
Voltage	12 V
Amp-Hour Rating	35 Ah
Charging Time	6-7 hours

Table 3 – Specification of Battery

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D. Motor Controller

The motor controller is an important component of the system. It is essential to control the amount of power supplied and to drive the BLDC hub motor. The controller converts the DC voltage from battery to an alternating voltage with variable amplitude and frequency that drive the hub motor at different speeds. It basically consists of MOSFET transistors and small microprocessor that vary from detecting any malfunctions with the motor hall sensors, the throttle, to protect functions against excessive current and undervoltage, which are ideal for protecting the system.

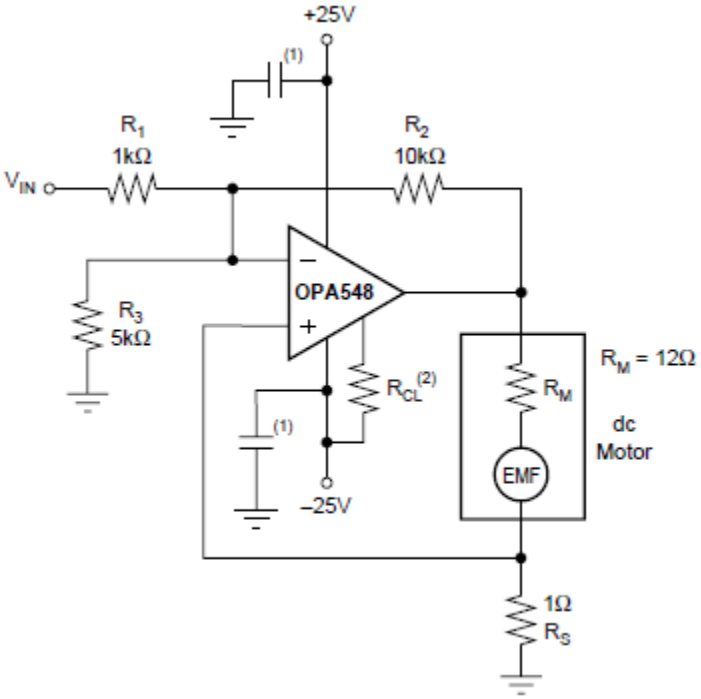

Fig 2 – Circuit Diagram of Motor Controller

System voltage (V)	24
Max load output current	25
End of charge voltage (V)	27.4
Boost charge voltage (V)	28.8
Ambient temperature (°C)	0-50

Table 4 – Specification of Motor Controller

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E. Accelerator/Throttle

The maximum speed of a bicycle is 30 kmph. It is required to vary the speed depending upon the road conditions & traffic. Therefore an accelerator or a throttle is necessary. Throttle allows us to drive the motor from zero speed to full speed. The throttle is fitted on right side of the handle bar and is connected to controller. The throttle converts DC voltage from battery to an alternating voltage with variable amplitude and frequency that drives the hub motor at different speeds. It consists of MOSFET transistors and a small microprocessor. This throttle is technically referred to as a Hall Effect type. The throttle has three wires contains a black, red, and green. The supply voltage is via red and black wires and is usually around 4 volts. Green wire voltage increases as the throttle is turned.This arrangement is replace the petrol engines, the gear box & the fuel tank in case of a two wheeler or chain sprockets, chains & gear shifting arrangement of a conventional bicycle being used by most common man.

Fig 3 – Throttle / Accelerator

Supply Voltage (V)	**24**
Return Voltage	4
Max Load Output Current	25
Three Wires Red, Green, Black	May differ from works. Fits for 24v supply

Table 5 – Specification of Throttle

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III.FACTORS AFFECTING EFFICIENCY

In general a solar panel is connected to a battery by connecting the positive of thepanel to the positive terminal of the battery and similarly the negative. A battery can be charged in such a simple manner. But here comes a problem during nights. During nights because of the potential difference there is a chance of current flow from the battery to the panel. This causes the battery to discharge to a particular level. To avoid such kind of problem, a diode is connected between the panel and the battery such that this diode acts as a one way passage from the panel to the battery. The poweroutput from the solar panel depends on the following Panel angle: The angle at which the sun hits the panels changes the amount of exposure. When the solar panels are mounted flat on the cycle and not faced to the sun, the power generated will be always lower than the rated amount. Anyways the sunlight is always diffused in the atmosphere which reduces this effect. Time of day: Time of the day plays a kind of important role on the power generated as the sun rays hitting a specific area is not the same the entire day. The rays are stronger and maximum power can be obtained between 11 a.m. – 3 p.m. Solar cell reflections: The power generated will be reduced if the solar cell reflects high amount of light rays. Hence a protective layer should be adopted on the top of the panel with a very low reflective coefficient. Clouds: Clouds play a very major role on the bicycle motion. Clear clouds makes the cycle efficient. It isn't exaggeration that the bicycle cannot be used well during cloudy days as the sun isn't available at its best.

1 Shadow Effect

While placing panels on the bicycle shadow effect should be considered because if shadow falls on the panel the amount of output power reduces. To avoid this effect and to increase the efficiency, panels are placed on roof top in this project.

2 Solar Panel Position

By mounting Solar panels on roof top efficiency can be increased because shadow effect can be reduced by this arrangement and also large solar surface area is possible. There are some disadvantages with this type of arrangement like weight increases and also air drag may increase. But, efficiency will not reduce.

3 Aerodynamics of Wind

Wind directions play a key role in speed of bicycle. If the wind is horizontal to the panels then there will be no issue, but if cross winds occur then more power will be drawn from the batteries to overcome the air drag.

4 Load on Bicycle

Speed of the bicycle always depends on the load mounted on it. If load on bicycle is within the limit then efficiency will be good. If load exceeds the particular limit of the bicycle then motor draws more power from batteries due to which efficiency decreases.

IV.CONCLUSION

A solar powered bicycle is practically designed and developed with an electrical efficiency greater than 80%. And the maximum speed of this solar assisted bicycle is 30 km/h, can be travelled up to 35 to 40 km with full charge of battery. It can be used by any age group people up to the weight of 120 Kg. By using this type of solar bicycles, pollution can be reduced and mainly fossil fuels can be protected and also good weight of loads can be pulled using this design. This solar bicycle is also cost effective when compared to conventional bikes.

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