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Design and Development of Solar Powered Bicycle

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***Abstract*- In today's era of technology, many transport utilities are present, but due to high rising prices of fuels like petrol and diesel, this is a major issue to afford them. Also, the pollution produced by the above fuels is a big challenge. Hence, a solar based bicycle has been discussed in this paper which works on solar energy and doesn't cause any pollution.**

***Keywords* - Solar Cycle, Solar Bicycle, New Generation Cycle, Eco Bicycle.**

I. INTRODUCTION

Mostly in India, the bicycles are going to be extinct from the market due to the boom of the petrol and diesel vehicles which are being launched in the market almost every week. But the prices of fossil fuels are increasing day by day and they also cause the pollution. In the present scenario of energy crisis, saving of the power has become a major issue [1]. To overcome the above problems, a solar bicycle has been designed. Solar bicycle is a battery operated bicycle which runs on the battery power, but the thing which makes it different is its charging features. The major charging point is specified by its name i.e. solar energy. The solar energy is the largest source of energy in the universe which is used now days to produce electricity in all over the world. Here, devices known as "Solar Panels" are used to convert the solar energy into the electrical energy by various means. A solar panel is connected to a control system consisting of various circuits which generate charge to drive.

General way of charging can also be used for charging i.e. a 220V, DC battery charger, which is basically used to charge a lead acid battery of motorcycles and cars, taking 200V AC supply as an input. Solar bicycle has concentrated its major focus to satisfy the user. Another major advantage in charging point of view is paddling. Just like a normal bicycle paddling has to be done for just 15-20 and the battery well get charged up to 20-22%. After this the bicycle can be operated using this battery power. As solar bicycle is a light weight entity and is as simple and smooth as a normal bicycle. This bicycle is designed for those who want one time investment of money, since there is no further expenditure except a general maintenance of the mechanical parts of the solar bicycle which includes oiling and greasing of the parts. This bicycle includes a Brushless DC Hub Motor which is operated on a set of DC Lead-acid battery. These batteries are rechargeable and can be recharged by the solar energy as well as by the electricity using a DC converter i.e. DC charger. Solar bicycle is operated by just turning and accelerator which is provided on the handle. It is safe as the speed is not as high as that of a racing motorcycle. Its starting acceleration is low and thus prevent a sudden accident. As the petrol and diesel prics are approaching the peak level and in futute it may be beyond the reach of amiddle class persons to use a fossil fuel driven vehicle. Further now a days every person needs a vehicle for transportation, so without vehicle life seems to be incomplete and if the fuel prices rise will not stop at this stage then it would become a curse for the future generation. So to check the fuel price rise and to save the fuel for future generations we have to introduce a substitute to it either as alternative fuel or change in operating mechanism of the vehicle. The solar energy is the largest source of sustainable energy which would be present in the future for thousands of years. Thus solar bicycle is a very efficient and useful entity for general purpose.

II. DESIGN OF SOLAR BICYCLE

Solar cycle consists of many mechanical parts which works on their specific principles and play a vital role in the formation of the solar bicycle. These individual

components are classified as parts of the solar bicycle which are need to be assembled in order to make a full working solar bicycle, This is a very important thing to be considered. As this bicycle is just only a symbol of innovative thinking, it consists of general life components used in different mechanical or electrical machineries but the only difference is that they are used here in different specifications and assembled in a self designed way. These components when used with an innovative idea, then the result comes out as electrical circuits supporting a mechanical machine to work in a different and better way, i.e. A Solar Bicycle.
The components used to make a solar bicycle are discussed below:

A. Frame :

A frame is a component serving as the basic building block for solar cycle. Solar bicycle's frame is very specifically designed so that every component should placed in the right place for maintaining proper weight balance, so that the centre of mass remains constant.

Fig.1. Frame

Frame of the cycle acts as a support for all the components of cycle, which are placed at appropriate provided places in the frame.

B. DC Brushless Hub Motor :

DC Motor is a mechanical machine which works on DC supply. The DC supply is converted in to mechanical energy, which may be in any form of force.Here it is in the form of armature rotation to which a shaft (the metal rod which can be seen from outside. It rotates because it is fixed with the armature coil) is fixed. This motor is a high torque low RPM motor which allows a higher weight to be pulled by a single brushless hub motor. Brushed DC motors develop a maximum torque when stationary, linearly decreasing as velocity increases [2].

Fig.2. Brushless Hub-Motor

The controller performs similar timed power distribution by using a solid-state circuit rather than the brush/commutator system. In the external-rotor configuration, the radial-relationship between the coils and magnets is reversed; the stator coils forms the centre of the motor, while the permanent magnets spins within an overhanging rotor which surrounds the core [3]. Here, we have used brushless motor of 36 V because it is more efficient in converting electricity into mechanical power as compare to brushed motors.

C. Battery Pack :

Every electrical machine which uses, stored form of energy in any way, it needs a set or more sets of battery packs. It is the stored form in DC type. Here the batteries used are Lead –acid batteries. This is because they are rechargeable and despite having a very low energy-to-weight ratio and their ability to supply high surge currents causes the cells to have a relatively large power-to-weight ratio [4]. These features, along with their low cost, make it attractive for use in motor vehicles to provide the high current. In this cycle there are 3 batteries of 12V each. They are used in series giving an output of 36V, 12Ah which is required by the brushless hub motor. As they are inexpensive compared

to newer technologies, they are used so that they meet all the conditions and specifications of the solar cycle and keep the cost to minimum.

Rated Voltage = 36V	Rated Current = 6.5A
Speed adjusting voltage = 0.8V-3.7V DC	Power cut off = Low Voltage

Fig.3. Battery Pack

D. Brushless Control System :

A control system is a device which controls the current supply in the whole setup or connection of the device. Because the controller must direct the rotor rotation, the controller requires some means of determining the rotor's orientation/position (relative to the stator coils). Here, a typical controller contains 3 bi-directional outputs (i.e. frequency controlled three phase output) are used which can be controlled by a logic circuit. Simple controllers employ comparators to determine when the output phase should be advanced, while more advanced controllers employ a microcontroller to manage acceleration, control speed and fine-tune efficiency. Controllers that sense rotor position based on back-EMF have extra challenges in initiating motion because no back-EMF is produced when the rotor is stationary [5].

Fig.4. Brushless Control System

Brushless control power is 250W. Table I shows rating of control circuit.

Table I

E. Power On/Off Switch Board :

The power board act as a switch from which from supply is turned on and all the circuit elements are activated and the current is supplied to the whole setup. This power switch board also contains a head light which can be used during the night driving as a light source. A key is provided in the switch board which is the switch for the control board. After turning on that key an instant supply of direct current from the battery is provided to the motor and all other equipments.

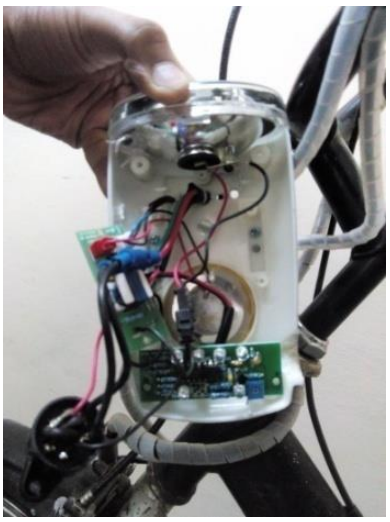

Fig.5. Power On/Off control

F. Back Wheel Drum Brake :

A drum brake is a brake that uses friction caused by a set of shoes or pads that press against a rotating drum-shaped part called a brake drum. The term drum brake usually means a brake in which shoes press on the inner surface of the drum. Where the drum is pinched between two shoes, similar to a conventional disc brake, it is sometimes called a pinch drum brake, Such brakes are relatively rare. A related type called a band brake uses a flexible belt or "band" wrapping around the outside of a drum [6]. The crescent-shaped piece is called the Web and contains holes and slots in different shapes for return springs, hold-down hardware, parking brake linkage and self-adjusting components [7].

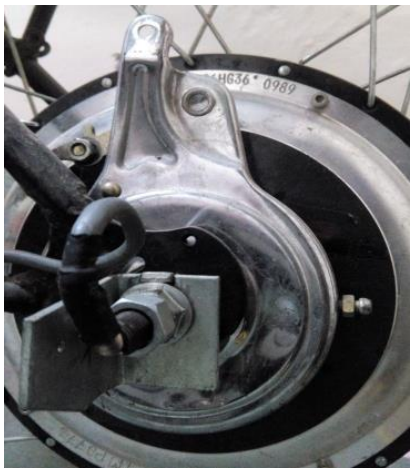

Fig.6. Drum Brake

The drum brakes are used here because they are more efficient at all the conditions than normal brakes and have longer life. These brakes always make a grip on the wheels, which help the cycle to move in an efficient way.

G. DC battery Charger :

A battery charger is a device used to reenergize a cell or (rechargeable) battery by forcing an electric current through it. Lead-acid battery chargers typically have two tasks to accomplish. When a typical lead-acid cell is charged, lead sulphate is converted to lead on the battery's negative plate and lead dioxide on the positive plate. Over-charge reactions begin when the most of lead sulphate has been converted, typically resulting in the generation of hydrogen and oxygen gas [8].

Fig.7: DC Battery Charger

This module converts the AC input of 230Volts, to a usable DC output greater than 36V for the charger circuit. The design includes an internal transformer, bridge rectifier and a filter capacitor. Transformer is needed to step down 230Vac to 16Vrms with a current of at least 3Arms. Hence, the transformer ratio is so calculated to be 16Vrms/220Vrms = 0.073.

H. Solar Panel :

A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar module can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Solar panel used in this cycle is of 150 watts. This solar panel charges the battery in 2.5 hours, which is a very less time as compared to the electrical energy supply in our houses. Solar panels are based upon the principle of photoelectric effect, which states that when the solar photons (energy in the form of packets) fall on the surface having bounded electrons then the exited state occurs for the release of electron in the form of energy. This phenomenon is used in the photocells or solar cells. Solar modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. The structural (load carrying) member of a module can either be the top layer or the back layer [9]. These silicon cells are having valance energy of 0.7 eV which is very less as required. Thus the solar cells get activated successfully in a very less time. Depending on construction, photovoltaic modules can produce electricity from a range of frequencies of light, but usually cannot cover

the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence, a lot of incident sunlight energy is wasted by solar modules, and they can give far higher efficiencies if illuminated with monochromatic light. Therefore, another design concept is to split the light into different wavelength ranges and direct the beams onto different cells tuned to those ranges [10].

Fig.8. Solar Panel

This solar energy is converted to the electrical energy and through the control system it is stored in the battery (mostly Lead-acid battery). This is known as battery charging; hence the battery is fully charged by the energy provided from solar cells.

I. Control System of Solar Panel :

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may prevent against overvoltage (above 36 V) , which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life [11]. The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery recharger. Circuitry that functions as a charge regulator controller may consist of several electrical components, or may be encapsulated in a single microchip; an integrated circuit (IC) usually called a charge controller IC or charge control IC. Charge controller circuits are used for rechargeable electronic devices such as cell phones, laptop computers, portable audio players, and uninterruptible power supplies, as well as for larger battery systems found in electric vehicles and orbiting space satellites. A charge controller is very important in a solar power system. It prevents damage to the rechargeable battery which can occur due to overcharging or due to deep discharging. Electronic switches are used to disconnect the solar panel when the battery is fully charged to prevent overcharging. Another switch disconnects the LED lamp or other load if the battery voltage is below a threshold to prevent deep discharging [12]. The micro energy systems are designed to work with lithium iron phosphate (LiFePO4) batteries because they have a much longer life expectancy than other rechargeable batteries.

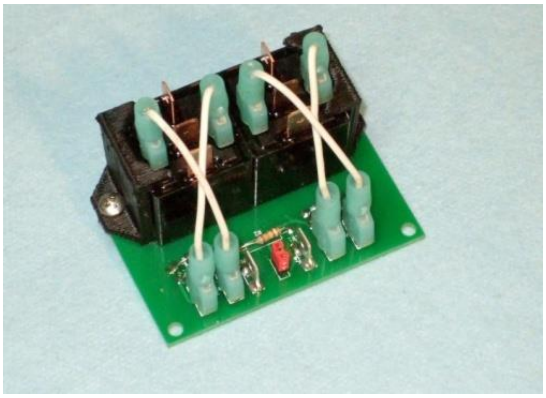

Fig.9: Control System of Solar Panel

In its simplest form, the job of a charge controllers is to make sure that the power source (such as a solar panel) 'plays nice' with the load (such as a battery). The simplest implementation of this is a single diode placed in between a solar panel and a battery. This ensures that the battery does not discharge into the solar panel at night. Table II shows the specifications of various parts:

Table II

Parts	Specifications
Solar Panel	150 Watt
Battery	36 V (12V+12V+12V)
Brushless Hub Motor	36V (Can work with 48 V also)
Charging Time	2.5 Hrs
Discharging Time	2 Hrs -2.5 Hrs

III. CONCLUSION

The assembling of solar bicycle is successfully completed and it has been found working as expected. This project is completed based on the battery and the charging is provided with the electrical ports i.e. 220V AC supply by using a battery charger for DC battery with a charging time of 4.5 hours. Battery is giving an output of 36 V DC which is able to run the bicycle at a speed of 20-25 kmph with a variable speed accelerator, with a discharging time of 3.15 hours, and running distance range of approx. 37 km.

Table III

Parameters	**Practical Reading**
Time taken by Battery for complete charging	2.5 Hrs (In case of Solar Panel) 4.5 Hrs (In case of DC supply)
Maximum Speed	(20-25) Kmph
Distance covered in full battery usage	37 Km

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