Energy Efficient Li-Ion Battery Based Electric Bicycle

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Abstract - This paper presents the energy efficient electric bicycle based on Li-ion dry type battery. Since last 50 years the fossil fuels reserves are continuously decreasing. So, it becomes very necessary to find out the solution to use alternate energy resources in reliable and efficient way. The increase demand for IC engine-based vehicles creates the pollution problems in many cities of India as well as in world. Hybrid electric vehicle is a best alternative to overcome the problem of air pollution and noise pollution. The PMDC Motor is used to drive the electric bicycle. The PMDC Motor eliminates the extra converter required if the motor used is of DC type. LI-ion battery is used for delivering high power storage capacity. A 24V controller is used for controlling inputs and outputs. It consists of one switch which on/off all system over battery. It is hybrid type bicycle which can operate on battery and pedalling. The hybrid nature of the bicycle makes it more energy efficient and eco-friendly.

Keywords: *Electric Bicycle, PMDC Motor, Li-Ion Battery, Controller, E-Bike, Eco-Friendly Vehicle*

1. Introduction

The main motive to layout the electric bicycle is to conquer the trouble with the pollution and with the financial system. Destiny for electric bicycle is the pleasant technical utility as solution for the higher world and upcoming generation. The E-bicycle is a battery-operated vehicle this is very comparatively cheap with low renovation price and less pollutants. E motorcycles are an attractive opportunity to each conventional bicycles and conventional cars, offering an environmentally pleasant, a laugh, efficient and handy manner to travel. E-bikes are pushed with the assist of battery that's coupled with electric motor. E- bicycle is the plug-in electric bike with two wheels. The electricity on which this bike works is saved in a rechargeable battery which drives the motor. Now a days these motorbikes are manufactured at a very large scale. Typical parts used in E-bike are PMDC motor, battery, controller, throttle, chain set [1]. A brushless DC motor uses electronic commutators and sensors rather than the mechanical commutation process, which is used in a brushed DC motor. The use of permanent magnet DC motor reduces mechanical losses and hence efficiency is improved. A permanent magnet DC motor has high dynamic response, better speed-torque characteristics high efficiency and more reliable as compared to a brushless DC motor [2]. A lithium-ion batteries allow an excellent thermal design to meet this requirement. As a result, a compact power source system can be constructed that can be expected to improve vehicle mount ability [3]. Through its high potential, and high energy density and capacity, this battery type has already contributed to improving our lives, and arguably will continue to do so in the years to come. However, battery development is very daunting and challenging in general, and perhaps particularly so when it comes to lithium-based cells [4]. Controller is just like a brain of the e-bicycle which controls power from battery bank to the different parts of the system i.e., motor, and accessories like headlight, backlight, horn and indicators and the power from charging ports to the battery [5].

2. Functional Block Diagram

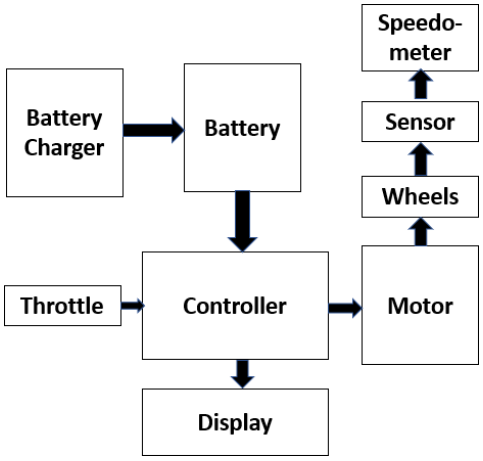

Fig.1: Block Diagram

Fig.1 shows the Functional Block diagram of Electric bicycle. When power supply using the battery is provided then the state of controller changes from OFF state to ON state. A controller can be called as the brain of the whole system as it carries out all the input and output signals which are essential for the functioning of the system. Controller receives throttle signals and transfer output signal to motor. It is a PMDC motor which operates on principle, "whenever a current carrying conductor placed in a magnetic field it experiences a force". Motor is attached to

wheel shaft of bicycle by using gearing and chain method. DC motors are in particular popular in high power and precise servo applications due to their reasonable cost and ease of control [6]. Throttle works as an accelerator. By using throttle accelerating torque of the motor increases and motor current increases. The power flow works in collaboration with power provided by the rider from the pedals [8]. Here, electromagnetic sensor is placed in between wheel spoke and wheel support frame which is connected to LCD display which Tracks the speed and distance are totally based on its stability in nature. It can check and verify the speed and distance, have many functions, average speed, maximum speed, time of riding, odometer, time clock, distance, scan, maintenance alarm etc. There is another display which displays the battery capacity in percentage and the battery voltage(8-70V) and is connected directly to the battery. The weight of the electric bicycle is approximate 10kg, it have around double the power output and the need to be pedalling at hills and road with high inclination [8].

2.1. Table 1: Specifications of components

Sr. No.	Name of Component	Specification
1.	PMDC Motor	24V,10A, 250W, 3800RPM
2.	Controller	DC 24V, 21A, 250W
3.	Li-Ion Battery	(24 to 28.80) V, 10Ah

2.1.1 PMDC Motor

The Permanent magnet DC motor is an energy efficient motor. It has very low mechanical losses, it is compact in size and easy to available in market for reasonable price. Due to its compact nature, it is easy to mount that motor on the bicycle. The direction of motor can be clockwise or anti-clockwise by reversing the motor connections. The no load speed of the PMDC motor is 3800 rpm; the rated speed of the motor is 3000 rpm.

2.1.2 Controller

The controller works as a monitor of electric bicycle, it monitors the operation of all the components are used. It consists of connections for motor, accelerator, brake, battery, battery charging, brake light and power lock.

2.1.3 Battery

Compared with traditional battery technology, lithium-ion batteries charge faster, last longer and have a higher power density for more battery life in a lighter package. Lithium-ion battery types can also be moulded into different shapes or unique spaces, making them ideal for high capacity and low power applications. The battery can be charged up to maximum 28.8V. A long life with full capacity for up to 2500 charge cycles and has low maintenance

3. Results

3.1 Time to Voltage Graph:

3.1.1. No load conditions

Table 2: Observation Table of no-load condition

Time in Min	*Voltage in Volts*
45	28
30	27
25	26
18	25
15	24
10	23
0	22

Table.2 shows the performance of battery voltage with respect to time, for No-load condition. Maximum charged voltage of battery is 28V and battery gets fully discharge at 22V.

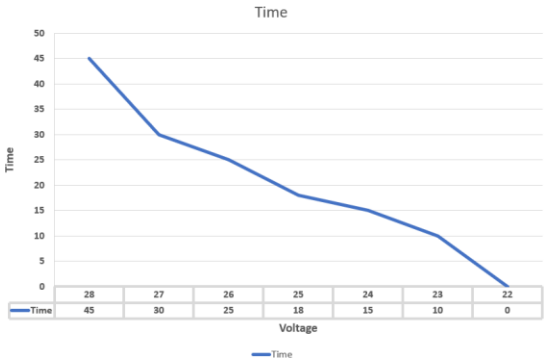

Fig.2: Time to Voltage Graph

In Table.2, the graph of time to voltage is shown, it represents the time in minutes on the Y-axis and voltage in volt in X-axis.
From the above Table.2 and fig.2 it is observed that the battery is discharged at 22V. Voltage is directly proportional to the time, as the voltage drops at the same instant the time of run also decreases. For a drop of 1 volt, it takes maximum time of 45 minutes and minimum time taken to 1Volt drop is 10 minutes. In fig.2, time taken to drop the voltage from 28V to

27V is 45 minutes and from 27V to 26V is 30 minutes respectively. Similarly, it takes 25 minutes to drop the voltage from 26V to 25V, it takes 18 minutes to drop the voltage from 25V to 24V and 15 minutes for the voltage drop from 24V to 23V. After dropping to 23V the battery will no longer perform its operation until it is charged again. So 23V is the minimum voltage required for battery to function.

3.1.2 On load condition

Table 3: Observation table of On-load condition

Time in min	Voltage in volt
40	28
28	27
22	26
15	25
10	24
5	23
0	22

In Table.3, the performance of battery voltage with respect to time, for No-load condition. Maximum charged voltage of battery is 28V and battery gets fully discharge at 22V.

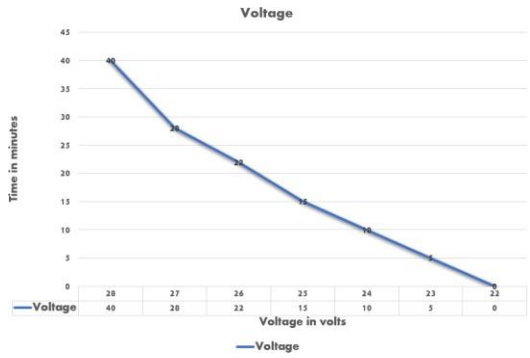

Fig.3 Time to Voltage Graph

In Table.3, the graph of time to voltage is shown, it represents the time in minutes on the Y-axis and voltage in volt in X-axis.

From the above Table.3 and fig.3 it is observed that the battery is fully discharged at 22V. Voltage is directly proportional to the time, as the voltage drops at the same instant the time of run also decreases. For a drop of 1 volt, it takes maximum time of 40 minutes and minimum time taken to 1Volt drop is 5 minutes. In fig.3, time taken to drop the voltage from 28V to 27V is 40 minutes and from 27V to 26V is 28 minutes respectively. After 23V battery will not perform any operations. So, 23V can be called as the threshold voltage of the battery.

3.2 Observation Table:

3.2.1 Range for variable loads.

***Table 4*: Observation table of bicycle performance**

Sr. No.	Person/kg	Distance/charge/km
1	40-50kg	40km
2	55-65kg	35km
3	65-75kg	30km
4	>75kg	< 30km
5	2 seats	25km

The Table 4 represents the range of the electric bicycle with respect to different loads. It gives a clear idea about how many kilometres it can be driven for a particular load or weight on it. For example, for a weight ranging between 40 kg to 50 kg the bicycle runs for an average distance of 40 kilometres. As the weight on the bicycle increases the range of it significantly decreases.

4. Conclusion

The idea of low-cost electric bicycle based on PMDC motor with Li-Ion battery is successfully presented. The results suggests that the PMDC motor can be the best alternative for light load applications. Also, the size of the battery, motor and their mounting position makes this electric bicycle aerodynamic in nature which assist the speed obtained by bicycle. The project has been able to design, analyse and assemble the electric bicycle which can achieve a top speed of 35 km/hr. For an average weight that is for the weight ranging between 55 kg to 65 kg the electric bicycle can travel for an approximate distance of 35 kilometres on a single charge.

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