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Design & Development of User Serviceable Battery-Operated Electric Bike with Adjustable Torque

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Abstract: - *The main aim of this paper is to present the idea of harnessing the electrical energy and use it in today's day-to-day human life. For human being travelling has become vital. In order to sustain in this fast-forward world, he must travel from one place to another. It is very important that time taking for travelling should be less, also it should be economical and easily available. With the rapid depleting resources of crude oil, there is need to find alternative source of energy. Taking all this into account, switching from conventional based fuels to using a non-conventional source of energy is a must. Electric bike which will be driven by using battery power and thus provide required voltage to the motor. The focus of this report is to system design of this electric bike. Therefore, the manufacturing of such bike is essential.*

Keyword: - E-Bike, Chain Drive, Battery, BLDC Motor, Throttle, Controller, Green energy.

1.INTRODUCTION

Humans require energy to execute various tasks. To fulfill this requirement of energy, fossil fuels have been the primary source of energy before the use of alternate resources. Nowadays vehicles run on IC engines which require fuels such as petrol, diesel, compressed natural gas, etc. As these fuels are near extinction and leave a lot of carbon footprint which eventually effects the climatic conditions, the use of green energy is the need of the hour. Due to this scenario, automobile sector has moved on to electric vehicles. Advancements in technology in electric vehicle industries have led in increasing the travelling range per charge, in considerably less money than conventional fueled power vehicles which are expensive.

In this context, new alternatives to the existing internal combustion engines are mandatory. So, vehicles with electric propulsion seem to be an interesting alternative. The vehicle on which we have been researching has a been proven efficient in transmitting torque which most of electric vehicles are lacking behind. This research describes a solution that was developed and studied to be applied in electric vehicles of individual use as bicycles. The solution proposes 3the combination of two sources of energy, batteries and supercapacitors, and two DC-DC converters. On board, batteries and supercapacitors store the energy. Anyway, the proposed topology considers that fuel cells should be used in two ways: replacing the set of batteries or to charge the batteries and the supercapacitors.

2. LITERATURE REVIEW

Studying through research papers from "International Journal of Advance Research and Innovative Ideas in Education." titling "Battery Operated and Self-Charging Bicycle." [1] we came to the idea of using the battery-operated bike which also charges itself on the run. This paper made us realize that the rotation of the rear wheel of the e-bike can help in generation of small amount which can be reused as charging the battery while the e-bike is on the run. Coupling a DC generator at the rear wheel of thee-bike using a chain drive mechanism can help in generation. As per the paper we referred, this method can result up to 20% more run of the e-bike on a single charging of the battery. The lead acid and lithium ion batteries were used as per the research paper. To overcome the e-wastage, we decided to use Lithium iron Phosphate Battery also known as LiFePo4 battery. According to one of the websites [2] we got the information from, LiFePo4 battery produce less e-waste, light in weight and consists a greater number of charge to discharge cycles than both lead acid and Lithium ion batteries. As per an article in New York times on Jan 31st, 2010 by J. David Goodman [3], senior citizens are most likely to get tired of cycling and finds it difficult to get back to their home after riding. E-bikes have played a vital role to switch a normal cycle to a motor-powered vehicle which can help senior citizens to get home with more ease. Using all these research papers and the websites, we came to a decision of start a research by combining the missing parts in all the above papers.

Following is a table of some reviewed papers which we used for references, respective work done by them is specified there.

TABLE 1: PAPERS REVIEWED FOR REFERNECES.

Sr. no.	Paper Title	First Author	Year	Work Done
1	The Electric Bicycle: Worldwid	Esther Salmeron-Manzano	2018	Safety concern about battery (lithium-based battery is safer

	e Research Trends			than lead acid)
2	Battery operated and self-charging bicycle	Mansuri Mo. Sohil J.	2018	Rear wheel can be coupled to a DC generator to charge battery while commuting.
3	Electric 2-Wheelers Play a Substantial Role in Reducing CO2 Emissions	Zhenying Shao	2012	Use of LiPeFo4 battery instead of lead acid battery to reduce the e-waste.

3. PROBLEM DEFINITION

Today, we are facing various problems regarding the fossil fuels powered vehicles and some of the electric powered vehicles. Some of the problems are mentioned below:

a. Transmission system

In today's automobile market, the scooters that are available have the continuous variable transmission system. This system is used by petroleum powered vehicles. On the other hand, the electric bikes use the direct hub motor which means no transmission system is required in the vehicle. This leads to uneven power and torque distribution to the vehicle when required. Also, it impacts the range of the vehicle.

b. Battery type

Most of the electric vehicles in market are either using lead acid batteries or Li-ion/polymer batteries. Both of these battery types have many drawbacks. As we know lead acid batteries contribute to hazardous e-waste and have poor charge density. Li-ion batteries have excellent charge density but they tend to heat up and can explode on puncturing or overheating. To overcome this, battery management system is used which results in more expense spent on battery maintenance and is complex to understand.

c. Battery output

Currently all the E- Bikes that are being sold have a fixed riding range. This is due to the lack of any regenerative methods which makes the bike totally reliant on the battery. Hence to increase the range we may have to increase the battery capacity leading to added bulk.

d. Serviceability

Majority of the E-Bikes have serviceability issues as it is quite hectic for the customers to maintain their bikes in case of a breakdown. Battery being the main suspect as they are fitted into the frame and cannot be removed without the assistance of the manufacturer.

4. OBJECTIVES

The primary objective of our project is to prevail over the problems mentioned before. Some of our proposed solutions to this problem are,

a. To generate variable torque while uphill climbing, by selecting different sprockets for transmission of power from motor to the rear wheel. Thus, giving a substitute to hub motors currently being used in the electric scooters.
b. Give assistance to battery by providing an external generator coupled to the rear wheel using chain and sprocket drive which acts as an alternator that helps the battery by providing a small amount of electricity to the driving motor.
c. To replace the lead acid, lithium ion and lithium polymer batteries on which the current electric vehicles are running, due to their poor heat carrying capacity and low number of charging and discharging cycles; with LiFePO4 (also known as Lithium Iron Phosphate) batteries.
d. To increase the range of bike by designing and selection of proper components.
e. Selecting a battery which is portable and charged even after it is separated from bike.
f. To create a user-friendly design which will easily serviceable and will have significantly higher range than the competition.

5. WORKING

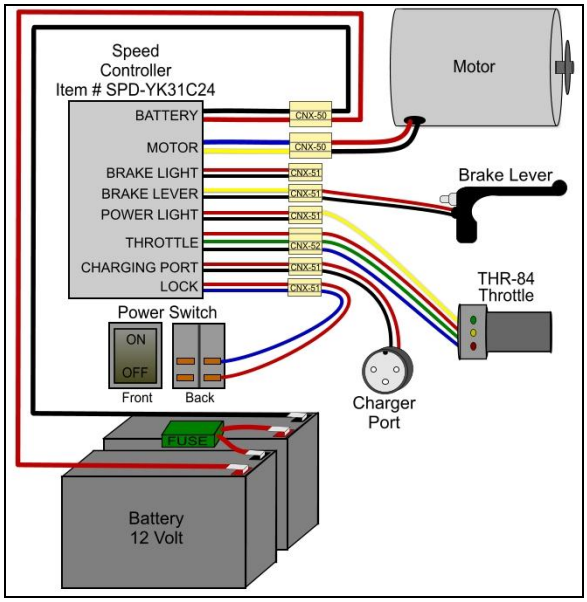

FIG 1: CIRCUIT DIAGRAM OF E-BIKE CONTROLLER

The above diagram illustrates the controller system of the e-bike. By this we understand the working principle of e-bike. The main components of e-bike are battery, permanent magnet DC motor, Dc motor controller and potentiometer (throttle).

Two batteries of 12v are connected in series so that it gives the output of 24v. The battery is connected to a 24v DC motor controller which have multiple output that connects to various other components of e-bike like potentiometer (throttle), DC motor, charging port, switch to ON/OFF the e-bike. The DC motor is mounted on the bike replacing the pedals on the bike so that the variable sprocket gear mechanism of the bike can be used. As the switch of the above circuit is turned ON, the power supply is given to the DC controller from the battery and controller is further connected to motor and throttle. The power supplied to the motor using controller is regulated using potentiometer (throttle) attached to the handle of the bike as in any 2 wheelers. As the regulated supply is given to the motor, the bike can run on variable speed. To achieve variable torque requirement conditions, the variable sprocket gear mechanism is installed which makes it easy for the rider to achieve variable speed and can get sufficient torque whenever required.

6. WORKING MODEL

FIG 2: WORKING MODEL MADE FOR TESTING

7. RESULTS

Battery pack used: - 24v 11Ah LiFePo4 battery pack.
Motor used: - Permanent magnet DC motor with following specifications-
No load current = 2.2A
Full load current = 13.4A
Assuming the bike is running at full load current and speed as 30 km/hr which is equivalent to 0.5 km/min

$$\text{Range} = \frac{\text{Battery Capacity (Ah)}}{\text{Load current (A)}} * \text{Speed(km/min)}$$

$$= \frac{11}{13.4} * 0.5 = 24.5 \text{ km.}$$

Thus, range of e-bike in a single charge is 24.5 km.
Since, after using DC generator to the rear wheel, we observed an increase in range of e-bike by 18%
Thus, the modified range of the e-bike is
= 24.5 + (0.18*24.5)
= 28.91 km equivalent to 29 km.
Thus, DC generator helped in increasing the range of e-bike.

8. CONCLUSIONS

- Use of Lithium Iron Phosphate battery also known as LiFePo4 battery made it possible to keep the e-bike light in weight in comparison with lead acid based e-bikes. Since LiFePo4 battery are less hazardous then lead acid and lithium ion batteries, the danger of explosion and heating issues are solved.
- Battery is light in weight, so, it is easy for the rider to charge the battery after removing it from the e-bike.
- With the help of variable sprocket gearing mechanism, the torque generation as per the rider's requirement was achieved and high speed at low consumption of battery is made possible.

- Coupling an DC generator to the rear wheel using chain drive mechanism helped in increasing the range by 18%.
- For counterbalancing ecological contamination utilizing of on – board Electric Bike is the most feasible arrangement. It can be accused of the assistance of AC connector if there is a crisis.
- The Operating expense of electric bike per/ km is less. Also, it is self-serviceable because of simple components being used in the model.

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BIOGRAPHIES

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