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Design and Fabrication of an Electric Bike for Single Occupant in India

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Abstract - *The current century is shifting toward electric vehicles from diesel/petrol vehicles. In this project, an "Electric Bike" is designed and fabricated for single occupant load by keeping in view uneven roads in Indian suburban areas. The lightweight of the E-Bike makes the ride comfortable for the rider. This project comprises with design and fabrication of an electric bike which makes the use of electrical energy as the primary source and solar energy if possible by attaching solar panels. It also highlights the design aspects of the bike.*
In this project, an electric bike assembly provides a lightweight, high-performance BLDC motor that is powered by a lithium-ion battery. There is a provision for charging the battery by connecting to a charger. The electrical power generated which is used to run the bike can give better fuel economy compared to a conventional vehicle. To make the E-bike more reliable there is a controller to protect the battery from heating issues by controlling drainage of power. Moreover, it operates the accessories of E-Bike like front light and indicator, etc. As per the design, it can travel about 30-35 kph. The speed sensor is given to detect the speed of the bike with the attachment of a digital speedometer.

***Key Words*: BLDC Motor, Lithium-Ion Battery, Controller, Speed Sensor, Digital Speedometer.**

1. INTRODUCTION

The Electric bike is a bike driven with the help of a battery coupled to the electric motor. The energy crisis is one of the major concerns in today's world due to the rapid depletion of petrol, diesel, and natural gas resources. In combination with this, environmental decay is an additional factor contributing to the depletion of resources which is an alarming notification [1]. As the rising demand and constantly increase of the cost of petrol and diesel have been ruling India. Therefore, the people of our society needs a solution, especially in India. Transportation is significant, and to augment it, people started seeking transportation by different means of energy.

Electric vehicles gave a solution to satisfy and fulfil the needs required by the society of India. Electric Bikes are two-wheeler vehicles that use electricity as the source of fuel. As a result, Electric motorcycles are noiseless with pollution-free, zero-emission and electrically driven with a high range of speed. The battery controls the operation and speed. For extending the variety of electric bikes and improve the production, fuel cells and petrol-electric hybrids could be introduced but in some parts, we should eliminate overall these petrol vehicles because this can harm our environment very badly, which are also on the verge of development and thus improving the efficiency of the electric drive system. The usage of electric bikes has turned out to be a solution for reducing pollution to a considerable extent. To burgeon the sale of e-bikes, they need to be enhanced in quality; hence, the electric bikes are designed with a frame that is light in weight compared to conventional bikes for efficacy in the present study.

Classifications of Electric Bikes

Therefore, very broadly e-bikes can be classed as:

- Pedal-assist only.
- Power-on-demand and pedal-assist.
- Power-on-demand only.

Range of Electric Bikes

Jim Turner tells [2], the range of electric bikes varies greatly. There is no common standard for determining electric bike ranges as there are EPA mileage estimates for cars. An electric bike can claim a long-range, but only if the rider pedalling is doing most of the effort or the bike is moving at a very slow speed. The range of electric bikes can be occurring when propelled by motor and battery alone and can be determined by these factors:

- The speed.
- The weight of the rider.
- The aerodynamic drag of the bike and the rider.
- The power capacity of the battery is measured in watt-hours.

Table -1: The following table shows the specification of various Electric Bikes in India.

S.No.	Name	Speed in Kph	Range in Kms	Motor Power in Watts	Weight in Kgs
1.	Ultraviolette F77	147	130	25000	158
2.	Revolt RV400	85	150	3000	108
3.	TVS iQube	78	75	4400	118
4.	Ather 450X	80	85	3300	108
5.	Bajaj Chetak	70	95	4080	118
6.	Ampere Magnus Pro	55	75	1200	82
7.	Benling Aura	60	120	2500	95

Working Principle

The Electric bike is a bike that is driven with thehelp of a battery that is coupled to an electric motor. It works on the principle that the electromotive force of a D.C. motor receives electrical energy stored in a D.C. battery.

Working: When the ignition switch of the electric Bike turns ON and throttling is given, it starts running with the help of the battery. Current flows through the controller which is used to monitor the battery voltage and shut down the drawn current if the battery is not charged. When the battery voltage is too low then it protects from over-temperature. Like this, the motor drawing current from a battery and starts working. The motor is a brushless DC motor. So, the current is directly drawn from the battery in DC form without using dynamo, and following this vehicle starts running.

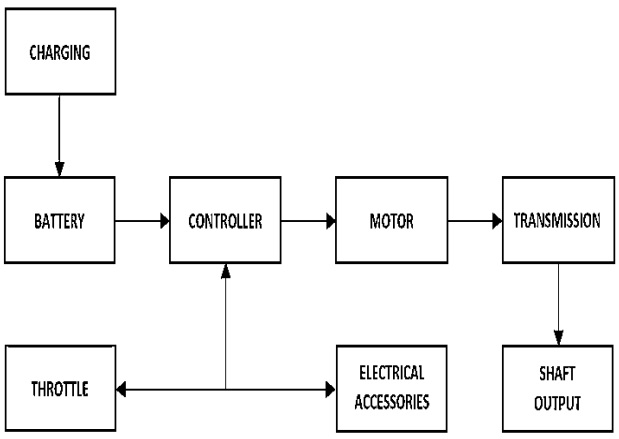

Fig-1: Flow Diagram of Electric Bike

2. COMPONENTS OF ELECTRIC BIKE

- BLDC Motor
- Controller
- Throttle/Accelerator
- Li-ion Battery
- Charger
- Ignition Switch
- Digital Speedometer
- Speed Sensor
- Chain Drive
- Sprocket

2.1 BLDC Motor

Brushless Direct Current (BLDC) motor is a type of synchronous motor, where magnetic fields generated by both stators and rotates have the same frequency. The life period of the BLDC motor is longer because in this no brushes are needed. As it has a high no-load speed, high starting torque, and few energy losses. The BLDC motor can be configured in three ways as 1-phase, 2-phase, and 3-phase. Three-phase motors are popular among all the other configurations and are widely used in Electric Bikes. As moving forward to the structure of a BLDC motor is divided into two parts:

• The main moving part of the motor is called the rotor, represented by a permanent magnet.

• The other part which is the fixed part called the stator is represented by phase windings of a magnetic circuit.

Fig-2: BLDC Motor

2.2 Controller

The controller acts as the “heart” for the electric bike. The controller can take energy from the battery and directs it to the motor in a very efficient way. By twisting the throttle, the rider can regulate the power that is being sent to the controller very easily, this, in turn, controls the speed of the electric bike.

There are two types of controllers designed to match either a brushless motor or a brushed motor. *Controllers for brushless motors*: Electric bikes require high initial torque and because of this, therefore, models that use brushless motors as used in our Electric Bike. The

controller assists a function of the sensor inputs, the vehicle speed, and the required force. The controllers generally allow input by means of a Hall Effect twist grip or a potentiometer.

Controllers have become much more intelligent. Regardless of the voltage source, current needs, or motor type, today's controllers are built with reliable solid-state electric components and can be designed to meet virtually any need and can easily be made compact to fit conveniently inside a motorcycle [3].

The controller sends signals to the hub of the electric motor in different voltages and these signals are then detecting the direction of a rotor which is relative to the coil of the starter and therefore the main function of speed control depends on the utilization of varied mechanisms.

Fig-3: Controller

2.3 Accelerator/Throttle

The throttle is simply a lever on handlebars that when we pressed it works just like the accelerator in bikes or cars to give quick acceleration as our requirement. The accelerator turns the sprocket which propels the electric bike forward.

When the accelerator/throttle is given and the engaged motor provides power and propels the bike forward. With the help of throttle, the speed of the E-Bike can be controlled very easily by giving it acceleration as per requirement.

Fig-4: Accelerator

2.4 Li-ion Battery

A Li-ion battery or lithium-ion battery is a type of rechargeable battery. Lithium-ion batteries are mainly used for electric vehicles. Energy is stored then released, through the electrolyte the lithium ions travel between these electrodes. The charger passes current to the battery. The ions of the lithium move from cathode to anode and therefore the battery is charged by a possible difference between two electrodes.

It uses lithium ions as a key component of its electrochemistry. Lithium atoms within the anode are ionized and they are separated from their electrons instantly. The lithium ions move from the anode then passes through the electrolyte until they reach the cathode during a cycle of discharge, after then where they again combine with the electrons and neutralize.

Because of their small size, batteries which are li-ion are capable of getting a high voltage and charge storage per unit volume and unit mass.

The newest technology in batteries. They are pretty comparable to other batteries, with the exception of two differences:

- They are a little bit lighter.
- Li-Ion batteries last about 800 full charge cycles before they need to be replaced. But they are a little expensive than other batteries.

Fig-5: Li-ion Battery

2.5 Charger

The charger is a voltage-limiting device. It is used to give energy into a secondary cell or to a rechargeable battery by forcing an electric current through it. The charging protocol depends on the type & size of the battery which is being charged. With the help of a charger, the battery is charged by plugging the charger into the battery.

Fig-6: Charger

2.6 On/off/Ignition Switch

An Ignition switch or a starter switch is in the control system of a motor vehicle that activates the main electrical systems instantly for the vehicle and its accessories.

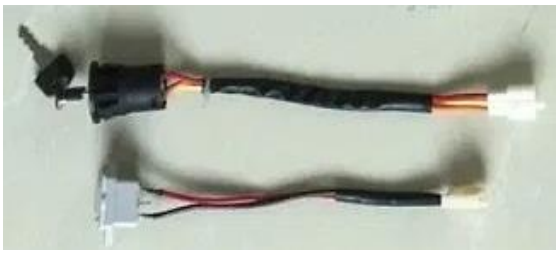

Fig-7: Ignition Switch

2.7 Digital Speedometer

A digital speedometer is a gauge that measures and displays the speed of a vehicle. The electronic speedometer depends upon the electronic rotation sensor which is placed near the transmission. A digital speedometer is a measuring device for a vehicle's speed and can measure the speed by indicating how fast a motor is propelling a vehicle.

Fig-8: Digital Speedometer [4]

2.8 Speed Sensor

Speed sensors keep track of your current speed and level of support. The speed sensor detects a rotational speed or forwards rotation after that it activates the motor to power the ride. A setting on the electric bike display determines how much power the motor uses to assist your pedalling. The torque sensor detects the force of your pedalling before activating the motor.

Fig-9: Speed Sensor [5]

2.9 Chain Drive

A chain is an array of links or assembly of links that are held together with each other with the help of pins which are made up of steel. This arrangement makes the chain more enduring and makes them work in a better way of transmitting rotary motion from one gear to another one.

Fig-10: Chain Drive [6]

2.10 Sprocket

A sprocket is a chain wheel that has teeth around its outer edge that fit into the holes in a chain. The sprocket which looks like a gear may differ in three aspects and the aspects are given below:

•The sprockets have many engaging teeth as compared to gears.
•The teeth of a gear slip & touch against each other but there is no slippage in the sprocket case.

Fig-11: Sprocket [7]

3. SELECTION OF MOTOR, BATTERY AND CONTROLLER

3.1 Specification of BLDC Motor

Rated Voltage: 48V

Rated Power: 750W

Efficiency: 80%

Weight: 2.9Kg

Colour: Silver

Wire Size: Long

Application: Electric Vehicle

Brake Type: Disc (Threaded Disc)

No Load RPM: 500 RPM

3.2 Calculation of Power Generation:

$Kerb\ Weight$: $90Kg$

$Passenger\ Weight$: $70Kg$

$Total\ Weight$: $90 + 70 = 160Kg$

$Tyre\ Specification$: $\frac{R16''}{2.5}$

$Rim\ Diameter$: $16 \times 25.4 = 406.4$

$Tyre\ Height$: $2.5 \times 25.4 = 63.5$

$Tyre\ Radius$: $\frac{406.4 + 63.5 + 63.5}{2}$

$= 266.7 \sim 267mm$

$Tyre\ Circumference$: $2\pi r$

$= 2 \times 3.14 \times 267 = 1.676 \sim 1.68m$

$Speed$: $35\ Km/h = 35 \times \frac{1000}{3600} = 9.7m/s$

$RPM\ at\ wheel = \frac{9.7 \times 60}{1.68} = 346.42 \sim 347\ rpm$

Bike Frontage Area

$Width$: $750\ mm$

$Height$: $1110\ mm$

$Person$: $600\ mm$

$= 750\ (1110 + 600)$

$1.28\ m^2 \times adjusting\ value = 1.28 \times 0.70$

$= 0.89\ m^2$

$Air\ Density$: $1.2\ Kg/m^3$

$Air\ Drag$: 0.82

$Coefficient\ of\ Rolling\ Resistance$: 0.02

$$\boldsymbol{Total\ Force = Rolling\ Force + Drag\ Force}$$

$Rolling\ Force = mgC_{rr}$

$= 160 \times 9.81 \times 0.02$

$= 31.3 \sim 32\ N$

$Drag\ Force = \frac{1}{2} \times air\ density \times front\ area \times v^2$

$= \frac{1}{2} \times 1.2 \times 0.82 \times 0.89 \times 9.7 \times 9.7$

$= 41.200 \sim 41\ N$

$Total\ Force = 41 + 32$

$Motor\ Power = Total\ Force \times v$

$Motor\ Power = 73 \times 9.7$

$= 708.1\ W \sim 708\ W$

$Hence, 750W\ Motor\ is\ selected.$

3.3 Specification of Battery

Volt: 48V

Capacity: 18Ah

Weight: 12-15 Kg

3.4 Calculation of Power:

$750W\ 48V\ Motor\ is\ selected.$

$P = V \times I$

$750 = 48 \times I$

$Current\ (I) = 15.62\ Amp$

Find out Watt Hour of Battery

$Battery\ \ Efficiency\ is\ approx.\ 90\%$

$$So, the\ battery\ Watt\ Hour\ required = \frac{750}{90}$$

$$= 833.33$$

$The\ Battery\ Aph\ is\ required:$

$P = V \times I$

$833 = 48 \times I$

$I = 17.36 \sim 18\ Aph$

$Hence, 48V\ 18Ah\ Battery\ is\ selected.$

3.5 Specification of Controller

Rated Power: 750W

Rated Voltage: 48V

Input Voltage: AC 160-300V, 47-63Hz

Input Current: 1.6A Max.

Brake: Low/ABS

Speed: 3 Variables

Auto Identification of the Hall Sensor: YES

Auto Identification of the phase angle of 60 and 120 degrees: YES

Fig-12: Fabrication of an Electric Bike

4. FUTURE SCOPE

In India, there is a massive scope of Electric Bikes. Some of India's biggest automobile makers take their steps into the electric vehicles segment. Electric vehicles like scooters and bikes are gradually going towards the mainstream. Start-ups like Tork Motorcycles, Emflux, Ultraviolette Automotive, Ather Energy, Orxa Energies, and Yulu add to the influx, supported and backed by the government's 'Make in India' initiative.

Moreover, the government has fixed a target of taking electric vehicles production up to 30 per cent of new cars and two-wheelers by 2030 in the country, from the current phase of less than 1 per cent. The sector holds immense scope since middle and lower-income groups of the country are often hit by the hike in fuel prices and hence are most likely to make the 'big switch' of the automobiles driven with petrol and diesel to electric vehicles.

Most vehicle makers resist bringing electric cars to India, the sales of electric vehicles are expected to exceed 2 million by the year 2030 in India.

Although electric vehicles currently make up a fraction of the total. As a result, the market is multiplying. As the Society of Manufacturers of Electric Vehicles report reveal that in 2017-18, sales of electric vehicles from a year ago doubled, while electric car sales dropped to 1,200 from 2,000 during the same period.

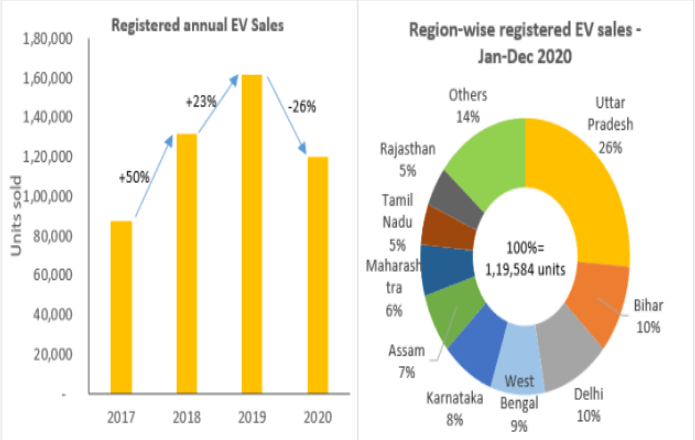

Chart-1: Scope of E-Vehicles in India [8]

5. CONCLUSIONS

This project may provide a solution for this existing problem since charging the battery is carried out as the vehicle runs. It is very much suitable for young, aged people to the need for society's economically poor class. The most important feature of this e-bike is that it does not consume valuable fossil fuels, thereby it can save money. It is pollution-free & eco-friendly, as it does not

have any emissions in it. Moreover, it is noiseless and the main feature is it can be recharged with the AC adapter in emergency and weather. The studies listed here can serve as a platform to improve electric bike performance if new drive systems are designed around critical parameters that will improve the system performance and can enhance the design of the electric bikes.

Electric bikes are as environmentally friendly because it is pollution-free, but nothing is ever perfect. Electric bikes are certainly a step in the good and right direction. If everyone used them to go around instead of petrol or diesel bikes, global warming might be less of a problem, and the world would be a far cleaner and healthier place as compared to the current time.

Furthermore, they can be used to compare existing drives in a systematic, comprehensive, and technical way.

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