

DEVELOPMENT OF ELECTRIC MOTOR BICYCLE

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering in Electrical and Electronic Engineering

By

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**DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600119

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DEPARATMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SUDHARSAN.S (REG.NO.38140052) AND VENKATESAPERUMAL.B (REG.NO.38140062)** who carried out the project entitled “**DEVELOPMENT OF ELECTRIC MOTOR BICYCLE**” under my supervision from NOVEMBER 2021 to MARCH 2022

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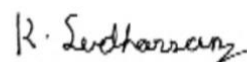
DECLARATION

We **SUDHARSAN.K (Reg.No.38140052)**, **VENKATESAPERUMAL.B (Reg.No.38140062)** hereby declare that the Project Report entitled “**DEVELOPMENT OF ELECTRIC MOTOR BICYCLE**” done by us under the guidance of **Dr. A. RAMESH BABU**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronic Engineering.

1.



2.



DATE : 20.04.2022

SIGNATURE OF CANDIDATES

PLACE : CHENNAI

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ABSTRACT

There is growing demand for Electric Motor Bicycle in India as there will be less air pollution, lower maintenance cost and reduced noise using Electric Motor Bicycle. The motive of this research work is to design a simple, cost-effective model of Electric Motor Bicycle with intelligent controller. The Electric Motor Bicycle is consisting of motor, battery and controller. In this BLDC motor is fixed in the rim of the rear wheel. The controller is connected to the motor and battery to control speed of motor and current. The Electric Motor Bicycle can be run with battery charge and also by pedalling. The simulation results are obtained by using ELECTRIC BIKE SIMULATOR. The experimental outputs are also demonstrated in hardware assemble set.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

A vehicle that is propelled by one or more electric motors or traction motors is known as an electric vehicle (EV). An electric vehicle can be self-contained using a battery, solar panels, fuel cells, or an electric generator to convert gasoline to energy, or it can be fueled by electricity from off-vehicle sources via a collector system. E-Cycle is an electric and power-assisted bicycle that is one of the bicycle industry's fastest-growing technologies. This bicycle has an electric motor to assist you in moving forward. As a result, you can ride it like a regular bicycle while exerting less effort. An E-Cycle motor works by turning on automatically when you peddle or throttle. There are two main types of E-Cycle

- Throttle assist
- Pedal assist

1.2 CLASSIFICATION OF ELECTRIC BICYCLE

1.2.1 TYPE 1 E-Bike

Pedal Assist is a type of electric bicycle that requires you to pedal in order to operate the motor. It's similar to a regular bicycle, except that it has a motor that detects when you're pedalling and kicks in to assist you. It's like if you've always had the best tailwind of your life. A throttle may or may not be present on this class/type of E-bike.

1.2.2 TYPE 2 E-Bike

Throttle Only is an electric bike with a throttle-controlled motor. You don't have to pedal to profit from the motor on these electrics. Simply crank the throttle when you need more power, and you'll be on your way. You'll be able to increase traction by accelerating in the middle of a corner. Of course, the less you pedal, the sooner the battery runs out of power.

1.2.3 TYPE 3 E-Bike

28 mph with Pedal Assist With a top speed of 28 mph, this Class/Type is the quickest "legal" E-bike. It is still deemed a "bicycle," and no driver's licence, licence plate, or

other documentation is required. It's technically a bicycle, and it's a lot of fun! Helmets are required by law. This category is best suited to someone who commutes by bicycle.

1.3 ADVANTAGES OF E-BICYCLE

- An E-bike is a bicycle that is environmentally friendly. It's the same as our regular bicycle. E-Cycle, on the other hand, runs on electricity rather than liquid fuel. There are no hazardous emissions released into the atmosphere. Electric bikes don't make any more noise for the same reason.
- Electric bicycles, in general, do not require any maintenance. Lubricate the drive system and inspect the chain and wheels on a regular basis to keep it clean.
- Riding an electric bike is currently popular and trendy. It is also the most effective way to reduce pollution.

1.4 OBJECTIVE

- To create an efficient E-cycle that can be used on many types of roadways.
- To adapt the E-cycle to various requirements.
- To design an E-cycle using 3Rs (Reduce, Reuse and recycle).
 - Reduce: Electric cycle can reduce the emissions.
 - Reuse: The cycle can be reused from old condition.
 - Recycle: The cycle has been recycled from scrap condition.

1.5 LITERATURE SURVEY

The constant news concerning the demise of fossil fuels, according to Adithya Kumar et al., (2016), has enhanced the importance of using electricity in the future. Electric bicycles will be used more frequently. The electric bike will be beneficial to office workers and those who ride short distances. The electric bike has a motor that assists the vehicle in moving ahead, and it is powered by a variety of sources. The motor is powered by the batteries, and the motor powers the vehicle. A battery charger is used to recharge the battery once it has been entirely discharged. We used a DC motor/generator mounted to the bicycle's rear wheel for

this project. The arrangement is powered by two sets of batteries labelled A and B. When one of the batteries is depleted, the remaining batteries will provide the necessary power. During this period, the wheel revolves, rotating the shaft of the dc motor/generator, which produces a voltage output. This voltage aids in the charging of the battery, improving the electric bike's range. It is environmentally friendly and pollution-free because it produces no emissions. Furthermore, it is silent and can be recharged using an AC converter in the event of an emergency or gloomy weather. It is ideal for young and elderly individuals, and it meets the needs of the economically disadvantaged. The most important feature of this bicycle is that it does not consume valuable fossil fuels thereby saving the money.

Annette Muetze, et. al., (2008) proposes that More attention needs to be paid to releasing electric bicycles from licensing. A unified standard/guideline for electric bicycle designers/manufacturers would encourage increased popularity while also ensuring that the quality of electric bicycles is not compromised. Custom-designed bicycles that are most efficient throughout a specific operating cycle, such as city, hill, and distance, as well as "speedy bicycles," could help to offset the extra cost and weight of bigger components. In this perspective, more research on battery and drive technology, as well as their use with electric bicycles, would be beneficial to the electric bicycle business. Even though electric bicycles' technical maturity has improved and continues to improve, there is still work to be done to make them competitive with other vehicles. More research is needed into the durability and lifetime of such bicycles, as well as the long charging times of batteries and the scarcity of charging facilities.

Carlos Tovar, et. al., (2009) proposes Novel The cities are living each day an accumulation of excessive traffic and noise. The air quality and health are two more components of city traffic that are badly damaged. Many air contaminants, like as carbon monoxide mono-oxide and suspended suspension particles, are primarily caused by transportation. It's a fantastic car that is both speedy and efficient while still being environmentally friendly. It is possible to enjoy a leisurely and enjoyable cruise while also arriving at locations (such as work) using this vehicle. Surprisingly, an e-bike costs the same as a regular bicycle. This means that when you buy this

vehicle, you have all of the features of a standard bicycle plus the added power of the battery, which allows you to go faster and for longer than you could on your own. The bicycle's electricity is designed to help the rider maintain a steady, safe speed on or off the road. Furthermore, the law considers this vehicle to be equivalent to a standard bicycle. That is to say, the user does not need a licence to ride an electric bicycle.

Ravina More, et. al.,(2011) proposes different models of calorie measurement need to be reviewed and tested to find which one is the most suitable to be adopted for a range of bicycles. For more information, To reduce the number of calibrations required for each particular cycle, researchers can look into developing a single model that fits all bicycles. Incentive-based ways for e-bikes can be tested, such as switching the bicycle from manual to electric mode once the calories burned goal has been met. It is necessary to consider a circuit that can accomplish the same. The anti-theft system is reliant on battery power. To do this, a more stable battery supply is required. The features will be implemented using the bicycle's existing power supply. The end product will be cushioned, waterproof, and temperature insensitive for a specific temperature range to protect it from harsh environmental elements. As a result, the project attempts to reestablish the bicycle as a more user-friendly and low-cost mode of transportation. For the simple bicycles, an attempt will be made to model a similar design.

1.6 SCOPE

The price of fuel is rapidly rising as the supply of fossil fuels decreases. We can save a lot of money in the long run and reduce global warming by converting to an electric bicycle. It also aids in our physical fitness. Electric Motor Bicycles are in high demand in India because they produce less pollution, have fewer maintenance costs, and produce less noise.

CHAPTER 2

DESIGN OF ELECTRIC MOTOR BICYCLE

Here the current from battery moves to controller where all the connections are made. When the power is given to the motor, it rotates the wheel using chain and sprocket.

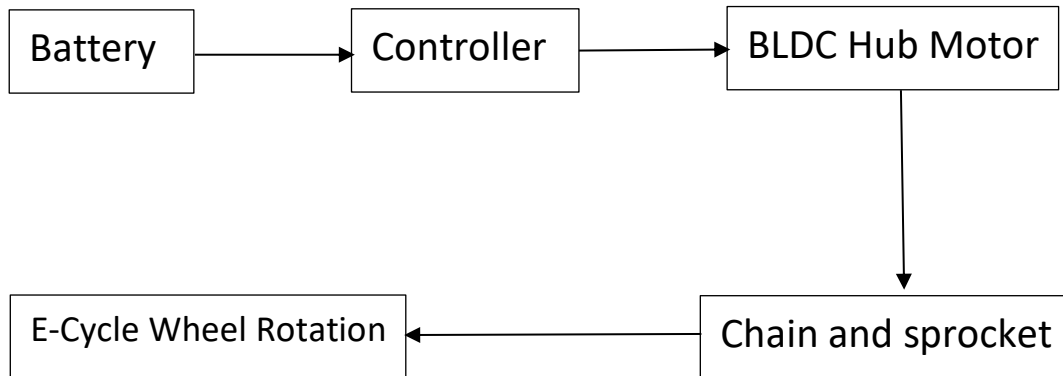


Fig.2.1 Block diagram of Electric Bicycle

2.1 HOW TO TURN ON OUR ELECTRIC MOTOR BICYCLE

Insert the key and turn on the ignition. Long press the power button in the instrument console, then the power supply will be active.

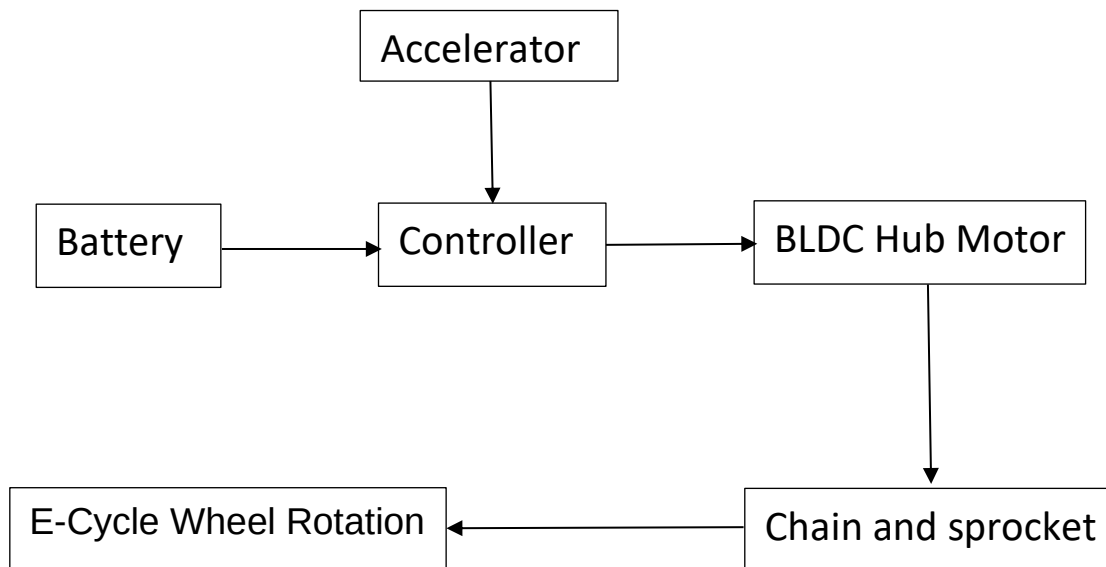


Fig.2.2 Block diagram of converting Electric Bicycle

When we rotate the accelerator to our desired amount, the controller takes the input and give the limited power to the motor and runs accordingly.

2.2 WORKING OF AUTO-CUT OFF BRAKES

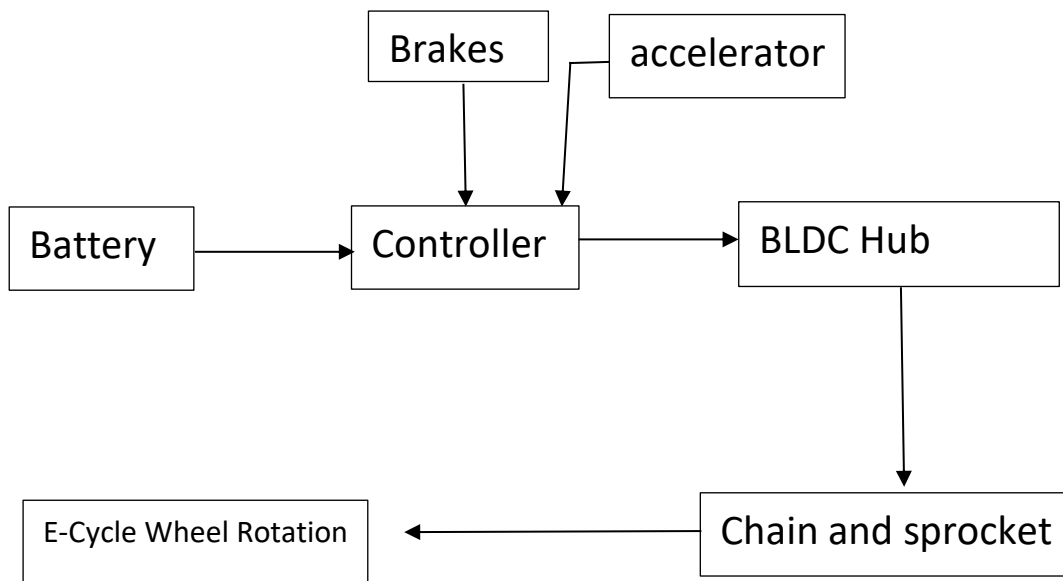


Fig.2.3 Block diagram for auto cut off brakes

When the brakes are applied during running/idle conditions, the controller cuts off the power supply to the motor till the brakes are engaged.

Working of cruise control:

When the E-cycle is running under a constant speed for 5 sec, the bike is changed to cruise mode and maintains the same speed. For changing back to normal mode, you can accelerate or slightly engage brake.

2.3 WORKING OF INSTRUMENT CLUSTER

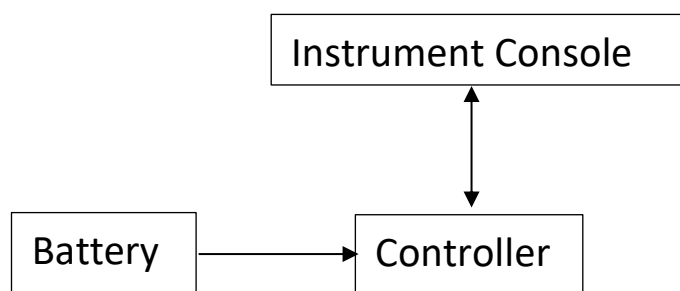


Fig.2.4 Block diagram for instrument cluster

The instrument console displays speed, battery level, odometer. It has three buttons (power button, motor power up button and motor power down button). Power button has two function, long press - for turning on ignition. Short press - for toggling between voltage level, trip meter and odometer.

2.4 WORKING OF LIGHT AND HORN

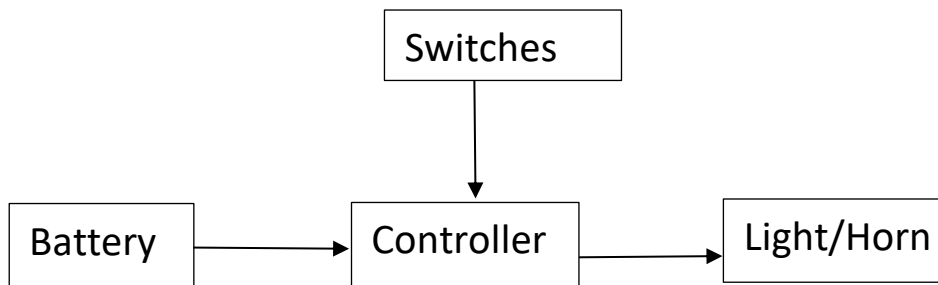


Fig.2.5Block diagram for lights and horn

There are two switches in handle bar one is for light and another is for horn. When the switches are pressed the controller reads it and sends the output to light/horn.

2.5 REQUIREMENT CALCULATIONS

2.5.1 Mass Range Calculations

Person Weight	=	100kg
Battery Pack	=	6kg
Motor & Controller	=	4kg
Cycle weight	=	10kg

Total = 120kg

So, Battery & Motor are required to propel the Bicycle with the weight of 120kg.

2.5.2 Motor Load calculation

F_p =Propulsion Force

F_{wf} =Windage & Friction Drag

F_d =Down force from Gravity

Consider the Grad @ 3.14%

$$\alpha = \tan^{-1}(\text{slope})$$

$$= \tan^{-1}(3.14/100)$$

$$= \tan^{-1}(0.0314)$$

$$\alpha = 1.8 \text{ degree}$$

2.5.3 To Finding F_d (Gradient Resistance)

$$\begin{aligned} F_d &= m * \sin \alpha \\ &= 120 * 9.81 * \sin 1.8 \\ &= 37 \text{ N} \end{aligned}$$

2.5.4 To Find F_{wf} (Aero Resistance)

$$\begin{aligned} C_d &\Rightarrow \text{Aerodynamic Area Co-efficient} = 0.74 \\ \rho &= \text{Density} = 1.225 \text{ kg/m}^3 \\ A &= \text{Frontal Area of Bicycle} = 0.37 \text{ m}^2 \\ V &= \text{Velocity of Bicycle} = 25 \text{ km/h} \Rightarrow 6.94 \text{ m/s} \\ F_{wf} &= \frac{1}{2} * C_d * \rho * A * V^2 \\ &= \frac{1}{2} * 0.74 * 1.225 * 0.37 * (6.94)^2 \\ F_{wf} &= 8.07 \text{ N} \end{aligned}$$

2.5.5 To Find F_R (Rolling Resistance)

$$\begin{aligned} C_R &= \text{Rolling CO-efficient} \Rightarrow 0.0041 (\text{for cycle}) \\ F_R &= C_R * mg \cos \alpha \\ &= 0.0041 * 120 * 9.81 * \cos 1.8 \\ &= 4.8 \text{ N} \end{aligned}$$

2.5.6 Total Propulsion Force, F_P

$$\begin{aligned} F_P &= F_d + F_{WF} + F_R \\ &= 37 + 8.07 + 4.8 \\ &= 49.8 \text{ N} \end{aligned}$$

$$\begin{aligned} \text{Propulsion Power} &= F_P * \text{Velocity} \\ &= 49.8 \text{ N} * 6.94 \text{ m/s} \\ &= 345.6 \text{ W} \end{aligned}$$

Thus, The Motor is to be 350 W

2.6 SELECTION OF BATTERY PACK

Range required: 30km

SPEED OF CYCLE: 25 km/hr

25 km for 1hr

30km for 1.2hr

➤ 345W Power to be extracted for 1.2hrs, to cover 30km distance

➤ Therefore,

$$345 \times 1.2h = 414wh$$

➤ 414wh battery Pack is required

$$36v \times 11.5 \text{ ah} = 414wh$$

(or)

$$48v \times 8.62 \text{ ah} = 414 \text{ wh}$$

2.6.1 Considering Cycle Applications And Safety

36V* 11.5Ah is selected

How many series? How many parallel?

Single cell=3.6v Normal Voltage

2.5Ah capacity

➤ 5 cells in Parallel = 5*2.5Ah

$$= 12.5Ah$$

➤ 10 cell group in series = 10*3.6v

$$= 36v$$

❖ 10S, 5P configuration will yeild 36v 12.5Ah.

$$C \text{ Rating} = 37.5(7.5 \times 5) / 12.5$$

$$= 3C \text{ For Discharge}$$

Charging allowed is 0.5C = 0.5*12.5

$$= 6.25 \text{ Amps}$$

$$\text{Safe current is } 0.2C = 0.2 \times 12.5$$

$$= 2.5AMPS$$

So, 42 V 2.5A Charger needed

2.7 CONTROLLER SPECIFICATIONS

$$36V \times A = 350W$$

$$X = 9.7A$$

- ❖ $9.7 < 37.5$ - Battery is safe
- ❖ $9.7 < 13 \pm 1$ – controller is safe

So 36v, 13 $\pm$ 1A controller needed – normal voltage

FULL CHARGE (42V)

$$\rightarrow 42V \times A = 350W$$

$$\rightarrow X = 8.3A$$

2.7.1 How Controller Works

$$42V \times (0 \text{ to } 8.3A) = 350W$$

$$41V \times (0 \text{ to } 8.5A) = 350W$$

$$40V \times (0 \text{ to } 8.75A) = 350W$$

$$31V \times (0 \text{ to } 11.3A) = 350W$$

So Required Voltage, A = $11.3 < 13 \pm 1$ Amp

So, find Spec arrived

350W motor

36V 12.5Ah (450Wh) battery pack

36V $< 13 \pm 1A$ controller

42V 2.5Amp charger is suitable for:

30Km range

25Km/hr

3.14% grade

120Kg cycle load

CHAPTER 3

SELECTION OF COMPONENTS

3.1 DC HUB MOTOR(BLDC)

This system uses a BLDC (brushless DC) motor with permanent magnets. The magnetic fields generated by both the stator and the rotor have the same frequency in a BLDC motor, which is a sort of synchronous motor. Because no brushes are required, the BLDC motor has a longer life. It also boasts a high starting torque, a fast no-load speed, and low energy losses. Three phase motors are the most common and commonly utilised in e-bikes out of a variety of layouts. Because the motor replaces the wheel hub, the system is chosen with a hub motor. Coupling loss is decreased, and mounting is simple without the use of chains or belts, resulting in a smaller and lighter e-bike.

Most electric vehicles (cars, bicycles, and wheelchairs) are powered by onboard batteries and a single, very basic electric motor that drives two or four wheels. However, some of the most recent electric cars and electric bicycles operate in a different manner. Instead of utilising gears or chains to power all of the wheels, they built a motor directly into the hub of each wheel, making the motors and wheels one and the same. A hub motor is exactly what it sounds like.



Fig.3.1 BLDC hub motor

3.1.1 Specifications

BLDC HUB MOTOR RARE WHEEL 36v, 250W

- Voltage:36 V
- Maximum current:10 A
- Maximum efficiency:85 %
- Torque:45 Nm
- Nominal power:250 W
- Peak power:350 W
- Maximum speed:30 Km/h

Hub motors are brushless motors (also known as brushless direct current motors or BLDCs), which have a half-dozen or more independent coils and an electronic circuit in place of the commutator and brushes. The circuit turns on and off the power in the coils, creating forces in each one that cause the motor to spin. Brushes press on the axle of a regular motor, causing friction, slowing it down, producing some noise, and wasting energy. Brushless motors are more efficient because of this, especially at low speeds. Getting rid of the brushes also eliminates the need to replace them when friction wears them down.

In a typical motor, the inner coil (named the rotor) rotates while the outside magnet (called the stator) remains stationary. The roles are inverted in this motor: the inner section with the coils is static, while the grey magnet spins around it. Now take a look inside to see how it all works: The grey outer shell (which is a magnet split into several portions and bent round into a circle) spins around the copper coils and circuit board as the electronic circuit transmits power to each of the nine copper coils in turn (which remain static).

However, between some of the coils are numerous tiny magnetic field sensors (also known as Hall-effect sensors). The Hall-effect sensors figure out where the north and south magnetic poles of the rotor are and which coils to activate to keep it spinning as the permanent magnets on the outer rotor sweep past them. The problem is that this necessitates the use of an electronic circuit to operate the motor, which is not required for a standard DC motor.

In the case of electric vehicles, the advantages are more clear. A normal car's metal weight (including the engine, transmission, and chassis) is roughly ten times that of its occupants, which is one of the reasons why cars are so inefficient. When

the hefty engine and transmission are replaced with hub motors and batteries, the car becomes much lighter and more energy efficient. Getting rid of the engine compartment also frees up a lot of room for passengers and their belongings; the batteries can simply be stowed beneath the back seat.

Hub motor vehicles are much simpler (mechanically speaking) than conventional vehicles. Assume you wish to go backwards. All you have to do is reverse the electric current instead of employing complicated gear setups. Backwards the motor spins, and backwards you go. On many cars, this is an expensive alternative because it necessitates extra gears and complicated driveshafts, but it's extremely simple to solve with hub motors. When each of a car's four wheels has a hub motor, four-wheel drive is immediately achieved. In theory, turning the four motors at slightly varying speeds (to aid handling and steering) or torque is simple enough (to move you through muddy or uneven terrain).

Hub motors are larger, bulkier, and heavier than standard wheels, and they alter the handling of an electric car or bike by increasing the unsprung mass (the mass not supported by the suspension), which theoretically results in increased shock and vibration, poorer handling, and a bumpier ride. That is, at least, the conventional wisdom. Engineers have discovered that vehicles with hub motors just need their suspension "tweaked" to compensate for the increased unsprung mass, and that this can even result in a better overall handling.

Because a single hub motor's unexpected failure could cause a vehicle to slew to one side, practical hub motors are often built up of many (usually four) independent sub motors, each delivering a fraction (a quarter) of the overall torque. Although this is a far safer design, it does add to the cost and complexity. Even so, with hub-motor electric automobiles, the two or four motors must be coordinated so that any serious failure in one motor can be compensated for by one or more motors on the opposite side.

Hub motors must survive in a considerably harsher environment than a traditional engine or electric motor, which is located high off the road and well covered inside

the engine compartment. They're un-sprung, so they're subjected to a lot of vibration, and they also have to withstand high-speed hits from boulders and stones, as we've just seen. They must deal with large temperature fluctuations (chilling cold from the outside air, boiling hot from sudden braking), as well as becoming entirely submerged in water or snow, down alongside the road. Isolated hub motors are a futuristic dream come true. Hub motors are more likely to be retrofitted to existing automobiles for the time being, therefore they must operate with existing friction brakes, suspension systems, and other components. This may necessitate design concessions that negate some of the benefits of hub motors in the first place.

Another issue is producing the exact amount of torque required (turning force). No matter what pace you're going on the road, a gasoline engine operates best when it's turning over quickly (producing a lot of revolutions per minute). Depending on whether you're starting from a stop, racing down the highway, going slowly uphill, or whatever, you utilise a gearbox to transform the engine's high revs into high torque (and low speed) or high speed (and low torque). Hub motors must be able to provide any speed and torque combination without the use of a gearbox; they are typically "direct drive." But there's a catch: on electric bikes, they're housed inside the hub, at the very centre of a huge spoked wheel. When you move a wheel's centre, its diameter acts as a lever, increasing the speed at the rim while decreasing the torque by the same amount (see our article on how wheels work for an explanation). You'll need a powerful engine to get enough torque, but not so powerful that it accelerates you too rapidly and jerkily or smashes your spokes.

Hub motors often obtain more torque by dramatically increasing the hub size (a larger stator and rotor provide more torque than smaller ones); as you can see in the electric bike photo above, the powered hub on an electric bike is far larger than the unpowered hub on a regular bike. Internal gearboxes (usually an array of planetary (epicyclic) gears in between the stator and the rotor) enhance torque in some hub motors, but many don't since they add weight, expense, mechanical complexity, and potential unreliability. Larger torque introduces a new issue: you must ensure that the rest of your wheel is sturdy enough to withstand the twisting forces delivered by a hub motor, especially if you're transforming an ordinary bicycle

wheel into a powered wheel. An electric bike's spokes are shorter and leave the hub at a tighter angle, putting them under additional stress. Assume you install an electric motor on the hub of a standard bicycle and turn it on. Because you're so heavy and there's so much friction between the tyre and the ground, the engine could just bend the spokes instead of propelling you! As a result, an electric bicycle often requires stronger wheels (possibly with stronger and more elastic spokes, altered spoke hole positioning, a thicker rim, or some other adjustment) than a regular bicycle.

3.2 CONTROLLER

The electric bike controller is one of the most important components of an electric bike; it is the e-brain, bike's managing the speed, start, and stop of the motor. It is linked to all other electronic components, including the battery, motor, throttle (accelerator), display (speedometer), PAS, and any other speed sensors that may be present.

Main chips (microcontrollers) and peripheral components make up the TA controller (resistors, sensors, MOSFET, etc). PWM generator circuit, AD circuit, power circuit, power device driver circuit, signal acquisition and processing circuit, over-current and under-voltage protection circuit, and signal acquisition and processing circuit are all found inside the controller.



Fig.3.2 Controller

3.2.1 Specifications

Compatible Motor	: Hub Motor
Body Material	: Aluminium
Cable Length(cm)	: 15
Current Limit(A)	: 15
Rated Voltage(v)	: 31 to 36
Rated Power(W)	: 350
Weight(gm)	: 211
Length(mm)	: 90
Width(mm)	: 50
Height(mm)	: 30

The controller gives the working voltage to the external device through the power circuit after attaching the battery, such as the switch +5V, headlamp +5V, and so on. Based on the input from the throttle or PAS, the PWM generates a corresponding pulse waveform for the MOSFET driving circuit. To control the motor speed, the MOSFET drive circuit controls the MOSFET circuit's turn-on and turn-off.

When the voltage is lower than the controller set value, the under-voltage circuit protects the battery from discharge, and the PWM circuit stops the output. The over-current protection circuit prevents the controller, battery, and motor from operating at higher currents. An electric bike controller's primary role is to take all of the inputs from all of the electric components (throttle, speed sensor, display, battery, motor, and so on) and determine what signal should be sent back to them (motor, battery, display).

The controller's many protection functions will differ from the controller's design. Some basic security functions are listed below. Protection against over-voltage. When the battery voltage becomes too high, the controller checks it and shuts down the motor. This prevents overcharging of the battery. Protection against low voltage.

When the battery voltage drops too low, the controller checks it and shuts down the motor. This prevents the battery from becoming overcharged. Protection against overheating. The temperature of the FET (field-effect transistor) is monitored by the controller, which shuts down the motor if it gets too hot. The FET power transistors are therefore protected. Protection against overcurrent. If the motor is receiving too much current, reduce the current supplied to it.

This safeguards the motor as well as the FET power transistors. Protection from braking. Even though the controller was receiving other signals at the same time, the motor shut down while braking. When a user presses both the brake and the throttle at the same time, the brake function wins.



Fig.3.3 Flow chart of Controller

If a motor has hall sensors, the controller should be hall-sensor or dual mode in most cases. The motor's Hall sensor will detect rotation, and the controller will send the appropriate voltage to the motor based on the sensor readings. It's more steady, uses less power, and has a higher starting torque. While a dual mode controller works well when the motor hall sensor is destroyed, the hall-sensor controller may prompt an error and stop working. In different controller designs, the wire types and wire terminals of the e-bike controller could be variable. To ensure proper wire connections, you'll need the electric bike controller wiring diagram.

These cables will be found on most e-bike controllers: motor, battery, brakes, throttle/ accelerator, or PAS Pedal Assist System (some controllers have both types of wires, some have one of them).

Some more wires are found in the advanced controllers, such as Display or speedometer, Three speeds, Reverse, LED light, etc.

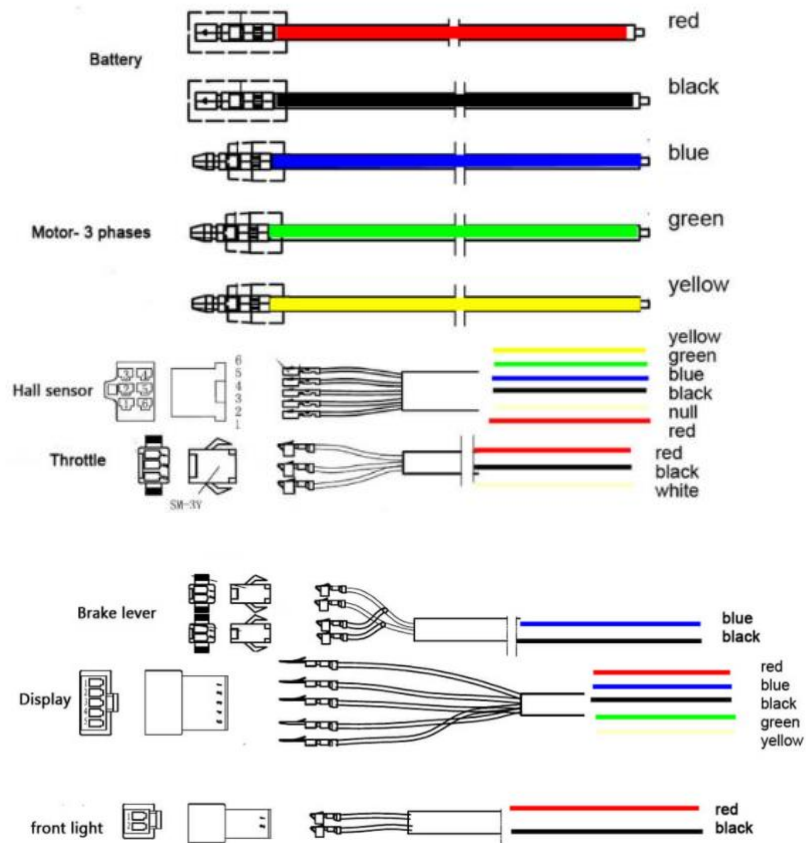


Fig.3.4 Controller Connecting wires

3.3 BATTERY



Fig.3.5 Battery

Li-ion batteries provide a variety of advantages over other high-quality rechargeable battery technologies (nickel-cadmium or nickel-metal-hydride). They offer one of the highest energy densities (100-265 Wh/kg or 250-670 Wh/L) of any battery technology available today. Furthermore, Li-ion battery cells can deliver up to 3.6 Volts, which is three times higher than Ni-Cd or Ni-MH technology. This means they can supply a lot of current for high-power applications, which is a good thing. Li-ion batteries are also low-maintenance, as they don't need to be cycled on a regular basis to keep their life. Li-ion batteries have no memory effect, which is a harmful phenomenon in which a battery can't remember a decreased capacity after repeated partial discharge/charge cycles. This is an advantage over Ni-Cd and Ni-MH batteries, which also exhibit this behaviour. In addition, Li-ion batteries have a low self-discharge rate of 1.5-2 percent each month. They don't contain the hazardous cadmium found in Ni-Cd batteries, making them easier to dispose of.

Li-ion batteries have supplanted Ni-Cd batteries as the market leader in portable electronic gadgets as a result of these benefits (such as smartphones and laptops). Lithium-ion batteries are also utilised to power electrical equipment in some aerospace applications, such as the new and more ecologically friendly Boeing 787, where weight is a major cost consideration. Much of the promise of Li-ion technology in terms of renewable energy derives from its prospective uses in battery-powered cars. The Nissan Leaf and the Tesla Model S, which are now the most popular electric automobiles, both employ Li-ion batteries as their primary fuel source.

Li-ion batteries, while their technological potential, have a number of flaws, particularly in terms of safety. Li-ion batteries have a proclivity for overheating and are susceptible to damage at high voltages. This can result in thermal runaway and combustion in some situations. This has resulted in severe issues, including the grounding of the Boeing 787 aircraft following reports of onboard battery fires. A number of shipping companies refuse to send batteries in bulk by plane due to the risks connected with these batteries. Safety systems for lithium-ion batteries are required to regulate voltage and internal pressures, which can increase weight and performance in some circumstances.

3.4 INSTRUMENT CLUSTER

We're utilising a cluster to show how much the battery is charging and how fast the bicycle is going. The instrument cluster is an important aspect of every vehicle because it is the vehicle's face that displays its current state. It can provide critical signals of electrical component faults (EFI/ISG related) in addition to basic vehicle information. Clusters can collect vehicle data using simple technologies like encoders as well as more complicated interfaces like CAN, SAEJ1850, and so on.

Although electric car instrument clusters have a lower system complexity, they must be more user-friendly, power-efficient, and cost-effective. To achieve the strict compliance standards, careful design and selection of cluster components is required. The MCU is the most common of the constituent components, with only a few vendors supplying automotive grade with the requisite feature sets.

FOCAN



Fig.3.6 display

3.5 THROTTLE

The throttle mode works similarly to that of a motorbike or scooter. You can propel the bike forward without pedalling by pressing the throttle. You can control how much power is produced with most throttles.

Electric bikes have a variety of throttle options, ranging from thumb throttle to full twist throttle.



Fig.3.7Throttle

3.5.1 Different Types of Throttles on Electric Bikes

- **Half-gripTwist:**This functions in the same way as a motorcycle or scooter does, with the throttle being twisted to activate it. It's the most common throttle for electric bikes. To accelerate the bike, the rider only needs to crank the throttle.
- **Thumb Throttle:**These are made to be simple to use. It's as simple as pressing a button to start the motor. Some have multiple buttons for controlling the bike's speed, while others only have an on/off switch.

Depending on how the throttle is engaged, different types of throttles perform differently. It's crucial to understand whether the throttle you choose can be used while the bike is still or only when you start pedalling.

To avoid injury if the user accidentally activates the throttle when stationary, some throttles can only be used while pedalling. This will help you avoid mishaps when you're first getting acquainted to your e-bike. Even when the bike is still, certain bikes allow you to utilise the throttle. They claim that starting from a stop without the normal heavy pedalling at start-up is a far simpler option. You may lift your feet, push the throttle, and go with this style of throttle.

3.6 LIGHT

Pedal-assist sensors and a throttle are commonly found on e-bikes. Some electric bikes contain a motor that only produces electricity when it is needed. The electric motor is engaged and operated manually in this situation, utilising a throttle that is often located on the handgrip, similar to those seen on a motorcycle or scooter.

These LED lights are long-lasting, simple to operate, and energy-efficient. The lights on offer are placed in electric bikes and create a bright dazzle of light in the evenings when there isn't enough light. Its one-of-a-kind lens design allows light to pass through the light cup before forming the whole reflection. This results in a more effective light beam and less light energy loss.



Fig.3.8 Light

3.7 HORN

A horn is a type of mu that consists of a tube, usually formed of metal and curved in a variety of ways, with one small end into which the musician blows and a wide end from which sound emerges. Unlike certain other bass instruments, such as the trumpet, the bore of a horn gradually widens over the course of its length, making it conical rather than cylindrical. In jazz and popular music, the term "horn" can apply to any wind instrument, and a section of brass or wood wind instruments, or a combination of the two, is referred to as a horn section.



Fig.3.9 Horn

3.8 BMS

The battery management system exists to manage the individual performance of each battery cell. Instead of allowing for individual performance, the BMS ensures that each battery cell drains, performs, and acts the same as all other cells throughout the battery.

ou will have consistent performance and full operation of your motor if you have uniform cell performance, which would otherwise be impossible. Your battery's life is also extended by the BMS. Individual cells without a BMS can overcharge, causing them to explode, or drain too far, rendering them unchargeable or hastening their overall deterioration. A defective BMS in your battery is the cause of failure if your Electric Motor Bicycle battery explodes or fails out much sooner than the manufacturer claims. In fact, a defective BMS is one of the most prevalent causes of your Electric Motor Bicycle's poor performance.

Tips to Manage Your BMS System:

- Don't Use a Charger that Isn't Rated for Your Battery
- Don't Leave Your Battery In Extremely Warm, Cold, or Wet Conditions
- Refresh the BMS System After Long Periods of Inactivity



Fig3.10 BMS

CHAPTER 4

DEVELOPING AND TESTING OF ELECTRIC MOTOR BICYCLE

4.1 SCRAP CYCLE

We went in search of cycle that was suitable for our design and budget and luckily, we found one which was in scrape condition. We saw the cycle that was in no condition to run. We got it to our place then changed few parts and done

repairs that made our cycle in running condition. Below the image is the day we got the cycle for the cycle shop.



Fig.4.1scrap cycle



Fig.4.2 conversion of scrap cycle

4.2 RUST PROTECTION

The cycle which be brought it to our place has serious rust issues and few alignment problems. So, we got sand paper and spray paint cans for paint works. First, we removed most of the rust and cleaned the cycle with the help of sand paper and then we resprayed our cycle giving it dual tone finish using spray paint and then we left it to get dry.



Fig.4.3 painting cycle frame

4.3 PARTS FOR CONVERSION

As we got our cycle and completed the maintenance work, we got ourself some parts for conversion of our cycle to an E-cycle. The parts contain,

- BLDC Hub Motor

- Controller
- Lithium- ion cells
- Half Grip Throttle
- Instrument cluster

4.4 MOTOR INSTALLATION AND MAKING OF BATTERY

Since we got all the components, we started to make our E-cycle. First, we decided to install motor. So, we removed the rear wheel and Spoke of the wheel was removed and aligned with motor. Then we installed rear wheel back to cycle. After completion of installation of motor, we moved to making of battery. Since we got it as cells not as a whole battery pack, we had to arranged cells and did welding between all the battery cells and the wire connections with Battery Management System (BMS) for the battery.



Fig.4.4 Motor fixed in rare wheel rim



Fig.4.5 creating battery using cells

Battery cells were connected in parallel using the clamps set that helps to fix the batteries in a fixed state. That was made with plastic as a frame.

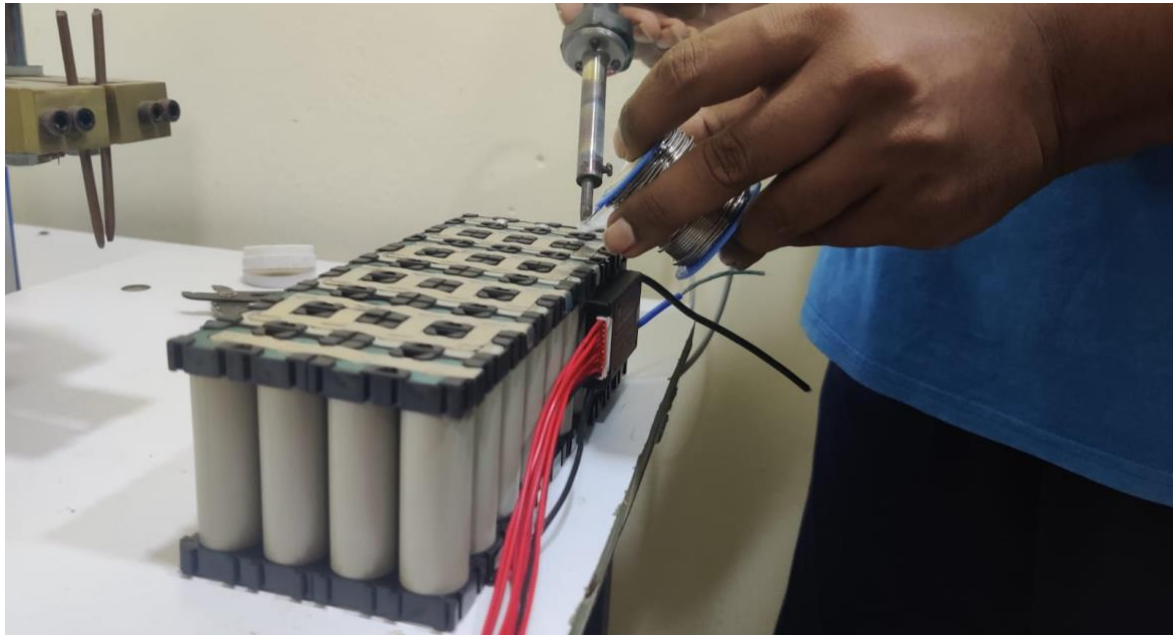


Fig.4.6 connecting cells

The cells were placed in frame and the cell were connected in parallel by soldering method. Then the cells connected in parallel were covered with a thin cover that protects the battery from the temperature and water resist. Then, the second layer is added on that layer with thick Polythene cover that help for the sealing of the cells.

Then the cells were connected with BMS that connects all the batteries to make the single output. One end of the BMS is connected to the cells connected in parallel and other end is output of the battery. Then, the cells were sealed with a plastic seal box. Only two wires come out from the sealed container that is the output wires.

The battery after the sealed using the multi-meter checking the battery current and voltage.



Fig.4.7 covering of cells

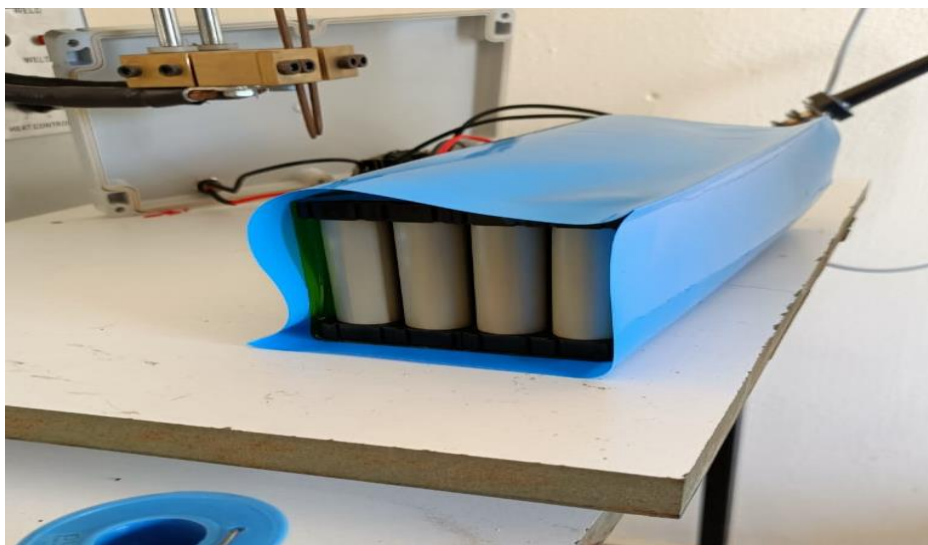


Fig.4.8 battery sealing

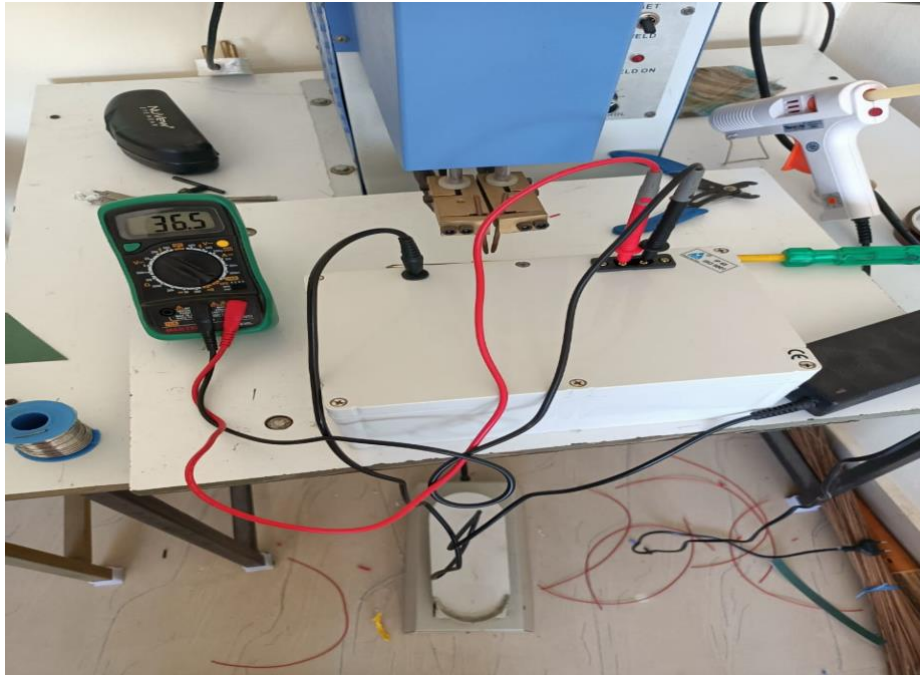


Fig.4.9 Battery testing

4.5 INSTALLATION OF BATTERY, CONTROLLER AND OTHER PARTS

After connecting all cell wires to BMS we heat sealed the battery pack using a sheet of PVC heat wrap. we added fuses if the charging current is more than 5 amp. Then we got an IP 65 box for storing the battery pack to get additional protection for the battery. We drilled and made two holes for charging and output of the cycle. We made a stand for the battery using scrap metal and placed it in centre rod between the cycle handle and seat. We installed throttle, switch, light and horn to the handle bar. Then all connections from all parts are connected to controller. And the controller is cover with another IP box and placed it under the seat rod.



Fig.4.10 Installation of battery, controller and other parts



Fig.4.11 After installation

4.6 TESTING OF THE ELECTRIC MOTOR BICYCLE

After completion of the conversion of E-cycle, we took it for testing it on road with different condition. So, the top speed was around 30 kmph with the range of 35+ km (depends on driving condition). The charging time was around 4hrs (0-100%).



Fig.4.12 Testing of Electric Bicycle

4.7 A TRIP TO THE COLLEGE AND FINAL FINISH

We went to college for showing our work to college staffs and asked for the review. Every one review on the performance of the cycle and gave it good comment. They asked us to change the battery placement. So according their review we have changed as per their needs. Finally, we painted it for final finish and added some sticker for enhancement of the looks.

We enjoy the ride to college that every one in our batch raided the Bicycle and share their feeling with others. Even the other also ride the Bicycle and share their feeling.

Then the faculty members raided the Bicycle and check the performance of the Bicycle. The acceleration speed was good enough that it can pickup the top speed as soon the throttle is twisted. It was a best moment while the faculty members raiding the bicycle it makes us happy.



Fig.4.13 Testing by Faculty

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

From this project we have done the conversion of scrap cycle to a good condition E-cycle which has almost every feature compared to every cycle in market. It is cost efficient and follows all the 3Rs of the eco system. We got a good lithium-ion battery which gives the range 40km (or even more, depends on the driving conditions.) and a top speed of 30 km/h.

6.2 FUTURE SCOPE

In future this cycle can be developed and can add additional feature like bi-directional controller which can regenerate battery power by peddling. Since our project has single directional converter but it can't be recharged while riding. So, the regenerative braking system won't be available. We can change to bidirectional converter and add that feature. We can even make an attempt to convert other vehicles like handicapped tricycle and cycle rickshaws.

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