

## A Review of Hybrid Electric Bike

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**Abstract** - There is increased interest in alternative vehicle technology due to various factors such as increased fuel consumption, depletion of available fuel resources, day by day increasing fuel costs and increased exhaust emissions due to increase in number of vehicles. This leads to increased demand of cleaner and highly efficient alternative vehicle technologies which can save energy resources. Hybrid electric vehicle is one such alternative technology which has potential to reduce use of fossil fuel and decrease exhaust emissions. A hybrid electric vehicle is a vehicle running on an internal combustion engine as well as on electrical energy. The engine can be refuelled like normal conventional vehicles and the batteries can be charged. A hybrid electric vehicle is a combination of hub motor, motor controller and battery along with the internal combustion engine. In this paper an overview of Hybrid Electric Vehicle is presented with emphasis on types, working principle and benefits of Hybrid Electric Vehicle. Hybrid Electric Vehicles has huge scope in upcoming future due to various advantages offered by it.

**Key Words:** Hybrid Electric Vehicles, Internal Combustion Engine, Hub Motor, Battery, Motor Controller.

### 1. INTRODUCTION

Due to certain economic and environmental aspects such as rising demand of fuel and increase in emissions of Green House Gases there is need to develop alternative vehicle technology. Due to more demand prices are increasing day by day. Green House Emissions from transport service is more than any other sector. So there is a need to reduce these harmful emissions.

Internal combustion engine is one of the greatest inventions of all time. Although internal combustion engine provides good performance and very good operating range there are certain problems such as poor fuel economy and pollution associated with it. Reducing overall fuel consumption and emissions is the need of hour. Although fully electric vehicles are the solution to the problem of rapidly depleting fossil fuels, there are various issues related with it. Availability of recharging stations is the main issue. Though electric vehicle

is emission free it is not able to travel long distances without recharging.

Although petrol vehicles can be used to cover longer distances with higher speed but it is inefficient in covering shorter distances with slow speed. Electric vehicles have shorter range. Currently electric vehicle producing industries are mainly focusing on increasing the range of electric vehicles. By using Hybrid technology range of electric vehicles can be increased.

A hybrid electric vehicle has a hub motor, battery, and control system in combination with internal combustion. Battery powers the hub motor. When we drive our bike in city we need to frequently start and stop it. In idling condition internal combustion engine consumes fuel without production of useful work. So it leads to more fuel consumption, unwanted exhaust gases and reduced efficiency. By using hybrid electric bike we can overcome these problems by simply shifting to electric mode. Also if fuel tank gets empty, bike can be driven on electric mode. During low torque requirement bike can be run on electric mode and during high torque requirement it can be switched to engine mode.

### 2. LITERATURE REVIEW

**Sharada Prasad N and Dr. K R Nataraj (2014) [1]** discussed the concern over the environment with respect to pollution and conservation of fuel resources in the world as the automobile industry is focusing on production fuel efficient and low emission vehicles with advanced technology. One of the important goal of modern design is to reduce fuel consumption and exhaust emissions. One such greatest innovation is Hybrid Electric Vehicle (HEV). The hybridization of a conventional combustion engine vehicle with an electric motor drive may greatly enhance the overall efficiency and achieve higher fuel with reduced emissions. Independent propulsions, ICE and electric motor were independently operated for combined effort derivation. The combined effort of ICE and Electric motor in propelling the vehicle more suitable for country like India was being analysed in this paper. It was concluded that the ICE will be

active in initial pickup and electric motor acts in supportive propulsion. The test area chosen was Mysore City, India

**Yasmeen Malik, Vikas Kumar (2017) [2]** described that with growing oil prices and changing environment, cleaner and supportable energy solutions are needed. Transportation sector contributes towards large amount of energy consumption and emission of toxic pollutants into the atmosphere. A hybrid electric vehicle (HEV) comprises of an internal combustion engine in combination with electric motor. Hybrid electric vehicles are greatly admired due to their ability to achieve similar performance as standard automobile along with prominently improving fuel efficiency and exhaust emissions. Different types of hybrid drive trains such as series, parallel and series parallel were explained in detail. Initially the analysis of hybrid electric vehicle performance was done with battery of higher amp-hr. capacity. In advanced state the converter circuit was implemented to reduce the battery rating. Different cases with different charging and discharging circuitry of battery were observed.

**Pappuri Hazarathaiyah, Y. Ashok Kumar Reddy, P. Vijaya Bhaskara Reddy and M. Sreenivasulu (2019) [3]** designed and fabricated hybrid electric bike. Hybrid electric vehicle is a vehicle which relies on batteries as well as on internal combustion engine for propulsion of the vehicle. It has great advantages over the conventionally used vehicles driven by gasoline engine only. Gasoline engine emissions are the primary source of air pollution. Their objective was to design and fabricate a hybrid electric two wheeler operated by battery and gasoline both. They fitted an electric wheel hub motor, battery and control system in old Bajaj Boxer bike to convert it into hybrid bike. It was finally concluded that for low power requirements battery drive is useful whereas for high power requirements gasoline engine is the best choice. As hybrid vehicles emit 50% less emission than conventional vehicles it plays an important role for reducing pollution to certain extent without compromising with efficiency. Thus the vehicle is best suited for the growing urban areas with high traffic as gasoline engine is least efficient and the energy from gasoline is being wasted away and creating unwanted pollution.

**N. Boopalan, Marlon Jones Louis and A.K. Nachimuthu (2014) [4]** proposed the need of hybrid electric two wheeler due to problems associated with modern automobiles such as fuel cost relative to mileage, pollution and less efficiency. The main goal of their project was to design and implement an efficient and less polluting vehicle. In their project of hybrid electric vehicle they combined the internal combustion engine of a conventional vehicle with the battery and electric motor for achieving, twice fuel economy as that of the conventional vehicle. In detail calculations and analysis was presented by them. They concluded that during high torque requirement IC engine mode is most preferred and during less load operation, vehicle can be run by means

of battery instead of engine. Further they were going to implement this idea in the Bajaj spirit bike and conduct performance test on it to verify their findings.

**Kamatchi Kannan V, Ponnurugan P and Chitra K (2020) [5]** described that the hybrid electric two wheelers have various advantages associated with it. Hybrid Electric Vehicle is an advanced vehicle having ability to operate on battery and electric motor. The motor helps to drive the wheel and also charges the battery when operated as a generator. The hybrid electric two wheelers have been popular in the market due to less CO<sub>2</sub> emissions. The main aim was to design and manufacture a hybrid two wheeler such as scooty which can be operated by means of both petrol and battery so as to reduce the cost and complexity involved in the existing hybrid vehicle technology and resolve the problem of short battery range present in electric bikes. According to their study it was concluded that the battery alone can be used at low-speed conditions where the engine is least productive and in case of accelerating or slope climbing, the Internal Combustion engine would give the extra force to drive the motor. For low power requirements battery drive is useful and for high power requirement the gasoline engine must be utilized.

**Balasubramani N, Hari Prasath S, Jagadeesh Kumar A, Karna Prakash S, Karun Prasath D (2018) [6]** designed and fabricated hybrid electric two wheeler. As the availability of fossil fuel resources is depleting day by day and pollution is also increasing globally with increased number of vehicles. It leads to the evolution of various alternative fuels and concepts, in that Hybrid Electric vehicle is one of the most effective system. The main aim of their project was to fabricate a hybrid electric two wheeler driven by both engine and electric motor. Hub motor powered by battery would drive the front wheel and the engine would drive the rear wheel. Performance of the fabricated bike was analysed and tested by driving it in engine mode, electric mode and hybrid mode and the results were compared with the conventional bikes. It was concluded that for low power application battery drive is suitable as engine is least efficient at low speed. For high power application gasoline engine is suitable as gasoline drive is most efficient at high speed. Therefore both modes of operation happen at maximum efficiency and the mileage of the bike gets enhanced. Due to reduced tailpipe emissions, the contamination of the environment by the harmful emissions decreases to a certain extent.

### 3. OBJECTIVES

- To provide easy switching between petrol mode and electric mode
- To extend the range of travelling
- To reduce exhaust emissions
- To reduce fuel consumption
- To reduce the running cost of the vehicle

#### 4. CLASSIFICATION OF HYBRID VEHICLES

##### 4.1 Series Hybrid-

A series hybrid vehicle is similar to a battery operated electric vehicle in design. They are fully electric vehicles that have a small petrol engine which acts as an on-board generator to re-power the battery back and provide additional driving range.

In case of series hybrid the drivetrain only receives the mechanical power from the electric motor, which is run by either a battery or a gasoline-powered generator. Here, the internal combustion engine drives an electric generator instead of directly driving the wheels. The generator both charges the battery and powers an electric motor that drives the vehicle. When huge amount of power is required, the motor draws electricity from both the battery as well as generator. These vehicles usually have large battery pack and larger motors with smaller I.C. engines.

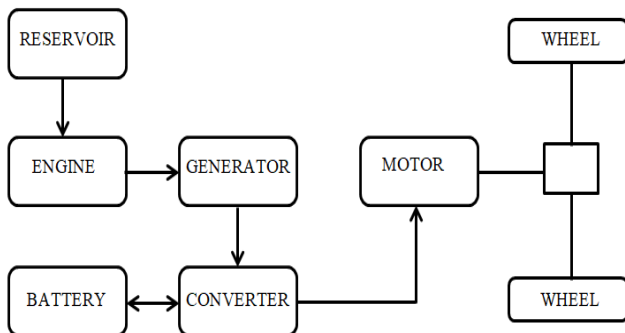


Fig -1: Block Diagram of Series Hybrid

##### Advantages:

- Low emission driving is possible.
- As the engine is not directly connected to the drive train it runs more efficiently.
- Suitable for short range travelling.

##### Disadvantages:

- There is a requirement of a full-sized electric motor, an electric generator and an IC engine, each of which can supply the required power for the vehicle.
- As the vehicle is only driven by the electric motor, it imparts more load on the battery pack so there is requirement of high capacity battery.

##### 4.2 Parallel Hybrid-

In the parallel configuration there are two power paths for the drive train, one from the engine and the other from the electric motor. During short range travel the electric motor can power the vehicle, while during long range travel the IC engine can power the vehicle. Thus the vehicle can have engine only, motor only, or a combination of engine and motor mode of operation. When only one of the two drives is in operation, the other will be disconnected through a clutch. The fuel tank, engine and the batteries, electric motor

connect independently to the transmission as a result, in a parallel hybrid; both the electric motor and the engine can provide power. The electric motor can also assist the engine during hill climbing and vehicle accelerations. Usually the combustion engine acts as the primary means of vehicle propulsion and the electric motor acts as a backup or torque booster.

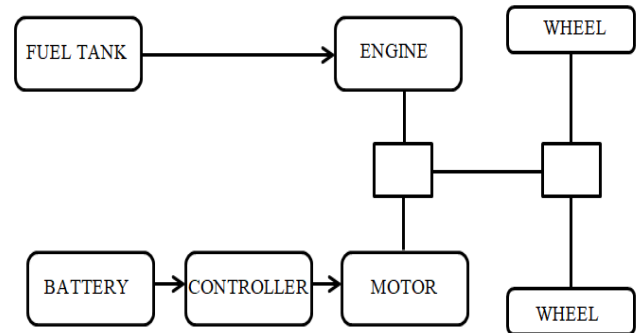


Fig -2: Block Diagram of Parallel Hybrid

##### Advantages:

- As both the engine and motor are connected to the drive train the battery size can be small.
- Easy switching in between the modes.
- The performance is very much similar to conventional vehicles due to the presence of dual power sources.
- As the engine is connected directly to the wheels, the inefficiency of converting mechanical power to electricity and back is eliminated, increasing the efficiency of these vehicles on highways.

##### Disadvantages:

- When battery pack charge is low the vehicle cannot get full acceleration from the electric motor.
- There is a need of complex control systems.

##### 4.3 Series-Parallel Hybrid-

In Series-Parallel Hybrid drive train there is a combination of the two drive train types, allowing for the vehicle to operate as all-electric as in case of a series hybrid, as an all combustion vehicle, or as a combination of the two as in case of a parallel hybrid. Series-parallel drivetrains combines the advantages and complications of the series and parallel drivetrains. With engine only and electric only options, the engine operates at near optimum efficiency more often. At low speeds it functions as a series hybrid vehicle, while at higher speeds, where the series drivetrain is least efficient, the engine takes over and energy losses are minimized. Power-split devices are incorporated into the power train. The power supplied to the wheels can be either mechanical or electrical or combination of both.

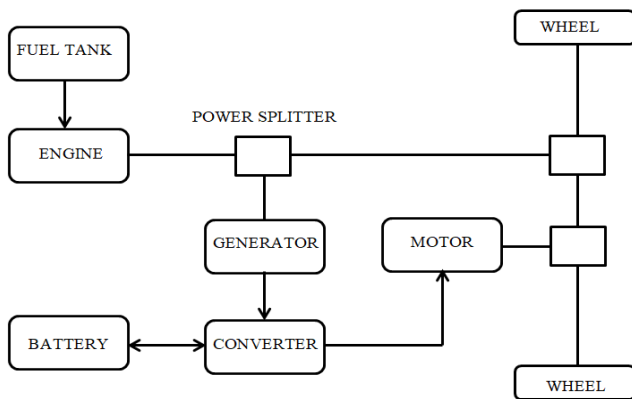


Fig -3: Block Diagram of Series-Parallel Hybrid

**Advantages:**

- It has both the advantages of the series and parallel configuration.
- It is capable of providing continuous high output power as compared to series or parallel powertrain.
- Dynamic in nature.

**Disadvantages:**

- As it needs more components such as an electric motor, an electric generator, an IC engine and a battery pack, for its operation it becomes more expensive.
- Very complex control system is required.

**5. COMPONENTS REQUIRED**

**5.1 Hub Motor:**

Hub Motor is the key component to power the bike in electric mode. It is an electric motor which is incorporated into the hub of the wheel and the motor drives the wheel directly. As it does not require a transmission system the transmission losses are reduced. The life of the motor is increased as it has no brushes to wear out. It also has various benefits such as compactness, high efficiency and noiseless operation. The construction of this motor is similar to three phase induction motor and conventional DC motor. Like all other motors this motor also has stator and rotor. The rear wheel of the bike must be removed and it must be replaced by the hub motor. Minor alterations must be done in order to fit the hub motor into the swing arm of the bike. The power rating of the hub motor must be found out by doing calculations.

**5.2 Motor Controller:**

A controller is used to connect all electrical components such as battery, hub motor, thumb throttle and various other accessories together. A controller is composed of main chip that is microcontroller and peripheral components such as resistors, sensors, MOSFET, etc. The controller basically acts as the “brain” of the entire system. It takes energy from the

battery and drives the hub motor. By twisting the throttle, the vehicle driver can regulate the power that is being sent to the controller, this, in turn, controls the speed of the vehicle.

The functions of the controller are-

- i. Current Conversion- It converts the direct current of the battery pack into 3 phase alternating current for the motor windings without which the motor could not spin.
- ii. Signal processing- Take all the inputs from all the electric and then determine what should be signalled in return to them.
- iii. Over-voltage protection- The controller monitors the battery voltage and shut down the motor when the battery voltage is too high. This protects the battery from over-charge.
- iv. Low-voltage protection- The controller monitors the battery voltage and shut down the motor when the battery voltage is too low. This protects the battery from over-discharge.
- v. Over-current protection- It reduces the current to the motor if too much current is being supplied. This protects both the motor and power transistors.

**5.3 Battery:**

Battery is one of the power sources for propulsion of Hybrid Electric Vehicles. Batteries are devices that consist of electrochemical cells and provide electrical energy converted from stored chemical energy. Earlier mostly lead acid, Nickel Cadmium, or NiMH batteries were used but modern ebike batteries are almost exclusively lithium-ion. Lithium ion battery offers high energy density while remaining relatively light-weight and compact in size as compared to all other existing battery types and do not have the 'memory' effect. Also it requires less Ah capacity for a longer range. The discharge rate of the lithium-ion battery is also less. The weight of the vehicle is also reduced to a great extent as lithium ion battery is light weight as compared to a lead-acid battery. The battery must be selected in such a way that the voltage of battery must match with operating voltage of hub motor. Ah capacity of the battery must be found out using calculations.

**5.4 Electric Throttle:**

Throttle is a device used to control the speed of the motor and accelerate the vehicle by means of controlling the voltage. Various types of throttles are available, such as twist throttle and thumb throttle. Twist throttle is actuated by rotating the handgrip and thumb throttle is actuated by pushing the lever. Throttle has a hall sensor fixed inside it. The moving part of the throttle has magnet with varying thickness on it. The output wire supplies voltage to the controller and it depends upon the position of the magnet and the voltage increases as the thickness of the magnet increases and the speed also increases. The voltage supplied to the controller by the output wire generally varies between 0.8V to 5V.

### 5.5 DC-DC Converter:

A DC to DC converter comes under the category of power converters and it is an electric circuit which converts a source of direct current (DC) from one voltage level to another, by storing the input energy temporarily and then supplying that energy to the output at a different voltage level. Battery used in regular petrol powered bike is 12V. Generally high capacity battery is used for powering the motor. If components such as tail lamp, head light, indicator light, horn are connected to high capacity battery they will get damaged. So voltage must be reduced to a certain level. The connections of the high voltage battery must be given as input to the DC-DC converter and the reduced voltage output from the converter must be supplied to the lighting accessories of the bike.

## 6. WORKING PRINCIPLE

The working of hybrid electric bike involves two modes, in engine mode the vehicle is driven by internal combustion engine and in electric mode vehicle is driven by electric motor. Mode selection can be either manual or auto switching based on speed.

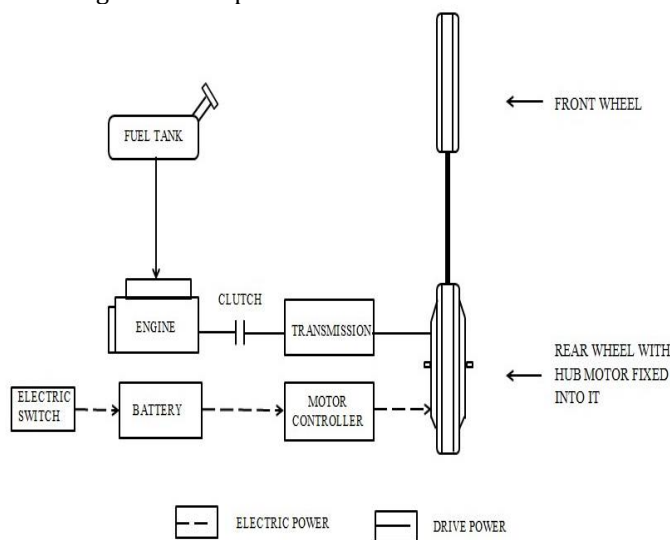


Fig -4: Schematic Diagram of Hybrid Electric Bike

### Engine Mode-

In engine mode the bike works as conventional bike. The engine supplies the power to the rear wheel with the help of transmission system as shown in the fig. Bike rider can control the speed of vehicle with the help of ordinary accelerator placed on the handle.

### Electric Mode-

In electric mode battery is connected to motor controller. Hub motor is fitted into the rear wheel of the two wheeler vehicle. It is also connected to the motor controller. As the motor rotates the wheel rotates too, thus, leading to vehicle motion. The speed of the vehicle during electric mode can be controlled with the help of electric throttle which is

connected to the controller. The throttle supplies input signals to the control in form of voltage. The controller then supplies the power to the hub motor and it starts to rotate.

## 7. BENEFITS OF HYBRID ELECTRIC BIKE

### i) Reduced Emissions-

Hybrid electric vehicles reduce the use of the fossil fuels. They even turn into zero carbon dioxide emission vehicles. As compared to conventional vehicles they save fuel and reduce carbon dioxide and nitrogen oxide emissions. The electric motor in a Hybrid Electric Two Wheeler allows its owner to drive with zero emissions.

### ii) Improved Efficiency-

HEV has the potential to be even more efficient than conventional vehicles due to limited use of the internal combustion engine in Hybrid two-wheeler and optimum working conditions, allowing the engine to be used at close to its maximum efficiency.

### iii) Reduced Running Cost-

HEV reduce fuel costs by using high capacity batteries that allow them to operate on electricity from the outlet for significant distances. Operating on electrical energy typically costs less than half as much as operating on petrol.

### iv) Operation at Maximum Efficiency-

In Hybrid Electric Vehicles modes of operation are maximum efficient to the conditions, i.e, at low speed and high traffic areas where gasoline engine is least efficient with a lot of energy wasted, vehicle moves with power from battery. For climbing slopes where high power is required and battery is inefficient, gasoline power is used for vehicle motion.

## 8. CONCLUSION

Hybrid Electric Vehicles which uses two sources of power-gasoline and battery can easily solve the individual problems associated with the gasoline engine and the electric vehicle. An electric vehicle is pollution free and is most efficient at low speed conditions mainly in high traffic urban areas. However, it cannot provide high power required during high speed conditions or in slopes of hilly areas. On the other hand petrol vehicles can cover longer distances with higher speed but it cannot cover shorter distances with slow speed in an efficient manner. Gasoline engine proves its efficiency at higher speeds on highways and waste a lot of energy in urban areas as driving in city involves frequent starts and stops of the vehicle. During idling state, the engine consumes more fuel without producing useful work thus leading to higher fuel consumption, less efficiency and unnecessary emission from exhaust of the vehicle. A hybrid vehicle solves these problems by combining the advantages of both the systems and utilizes both the power sources at their efficient conditions. This hybrid combination also makes the vehicle dynamic in nature. It also helps to reduce toxic emissions

and achieve better fuel economy. As the bike can run on both the modes the mileage of the bike also greatly increases which is an added advantage. Hybrid bike is very much profitable as it solves the problem of increasing fuel cost by reducing the running cost.

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