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Retrofitting of IC Engine Scooter into Hybrid Scooter

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ABSTRACT: The project "Retrofitting of IC Engine Scooter into Hybrid Scooter" aims to convert an existing internal combustion engine (ICE) scooter into a hybrid scooter by adding an electric motor and battery system. The hybrid scooter will be capable of running on both gasoline and electric power, providing improved fuel efficiency and reduced emissions. The project involves designing and integrating the hybrid system into the existing scooter, testing and optimizing its performance, and assessing its impact on the environment and economy. The retrofitting of an existing ICE scooter into a hybrid scooter offers a cost-effective solution to reduce the carbon footprint of transportation, without requiring the purchase of a new vehicle. Here, by using scooter that has 100 cc petrol combustion engine. The front wheel is replaced by an electric hub motor. It becomes a 2-wheel drive scooter with the hub motor driving the front wheel and conventional engine powering the rear wheel. Our main aim is to increase mobility and to improve the performance efficiency of existing vehicles. System proposes three switching modes here; Economy mode (Propulsion using motor only), power drive mode (propulsion using engine only) and hybrid mode.

KEYWORDS: Retrofitting, Hybrid electric vehicle

I. INTRODUCTION

The increasing global demand for energy and the growing concern for the environment have led to a need for more sustainable transportation options. With conventional internal combustion engine (ICE) vehicles contributing to air pollution and climate change, alternative modes of transportation have become increasingly popular. Electric vehicles (EVs) have gained significant attention in recent years, but their high cost and limited range remain significant barriers to widespread adoption. Retrofitting existing vehicles with hybrid systems provides a cost-effective solution to reduce emissions and improve fuel efficiency. The project "Retrofitting of IC Engine Scooter into Hybrid Scooter" aims to convert an ICE engine scooter into a hybrid scooter by integrating an electric motor and battery system. This project offers an opportunity to enhance the performance and sustainability of existing vehicles without the need for new vehicle purchases. The project will involve designing and integrating the hybrid system, testing and optimizing its performance, and evaluating its environmental and economic impact. Retrofitting existing vehicles with hybrid systems is a crucial step towards achieving sustainable transportation systems, and the project aims to contribute to this goal.

The internal combustion engine is one of the greatest inventions of mankind. The conventional vehicles with ICE provide a good performance and long operating range. However, they have caused and continue to cause serious problems for poor fuel economy, environment pollution and human life. Reducing fuel consumption and emissions is one of the most important goals of modern design. The hybridization of a conventional combustion engine vehicle with an advanced electric motor drive may greatly enhance the overall efficiency and achieve higher fuel with reduced emissions. Considering the urban status in India, a well-organized and fuel-efficient scooter has to be designed and developed. HEV are the vehicles with more than two energy sources are present. The major challenges for HEV design are managing multiple energy source, highly dependent on driving cycles, battery sizing and battery management. HEV's take the advantages of electric drive to compensate the inherent weakness of ICE, namely avoiding the idling for increasing the fuel efficiency and reduce emission during starting and speeding operations, to use regenerative braking instead of mechanical braking during deceleration and down slope driving. HEV can meet customer's need and has added value but cost is the major issue. These vehicles are of high cost and certain program should be supported by



the specific government for marketing HEVs. The HEVs are classified into two basic kinds-series and parallel. Recently with introduction of some HEVs offering the features of both series and parallel hybrids, the classification has been extended to three kinds- series, parallel and seriesparallel. Series Hybrid is one in which only one energy converter can provide propulsion power. The heat engine or IC engine acts as a prime mover in this configuration to drive an electric generator that delivers power to the battery or energy storage link and the propulsion motor. In a series HEV, the internal combustion engine never directly powers the vehicle. Instead, the engine drives an electrical generator, and the generator can either charge the batteries or power an electric motor that drives power to the wheels. Series HEV is the simpler type, where only the electric motor provides all the propulsion power. A downsized internal combustion engine on board drives a generator, which supplements the high voltage battery and can charge it when the state of charge (SOC) falls below a minimum threshold. The power required to move the vehicle is provided solely by the electric motor. Beyond the internal combustion engine and the electrical generator, the propulsion system is the same as in a BEV, making electric motor power requirements the same as for in the BEV Parallel Hybrid is one in which more than one energy source can provide propulsion power. The heat engine and the electric motor are configured in parallel, with a mechanical coupling that blends the torque coming from the two sources. In a parallel HEV, the internal combustion engine and the electric motor can be connected to the driveshaft through separate clutches. Power requirements of the electric motor in the parallel hybrid are lower than that of series hybrid, because the internal combustion engine complements for the total power requirement of the vehicle. The propulsion power may be supplied by the internal combustion engine, by the electric motor, or by the two systems in parallel. Series and parallel hybrids come in a variety of types. The mission of the vehicle and the optimum design for that mission dictate the choice. If the HEV is to be basically an EV with an IC engine-assist for achieving acceptable range, then the choice should be a series hybrid, with the IC engine ensuring that the batteries remain charged all the time. On the other hand, if the HEV is to be basically a vehicle with almost all the performance characteristics and comforts of an IC engine vehicle, but with lower emission and fuel usage standards, then the choice should be a parallel configuration. Parallel HEVs have been built with performance that is equal, in all aspects of normal operation, to that of a conventional car. However, some series HEVs have also been built that perform nearly as well as IC engine vehicles. In a series-parallel HEV, a power split device (PSD) allocates power from the ICE to the front wheels through the driveshaft and the electric generator, depending on the driving condition. The power through the generator is also used to charge the high voltage battery. The power through the generator is used to charge the batteries. The electric motor can also deliver power to the front wheels in parallel to the ICE. The inverter is bidirectional and is used to charge the batteries from the generator or to condition the power for the electric motor. For short bursts of speed, power is delivered to the driveshaft from the ICE and the electric motor. A central control unit regulates the power flow for the system using multiple feedback signals from the various sensors.

II. PROBLEM STATEMENT

- Retro Fitting of Electric Kit in existing IC engine Scooter for making electric and petrol scooters.
- Development of such model which have a 45 km/hr speed, 40 km/charge electric mileage and 40 km/L petrol mileage
- Reduction of running cost of scooter as petrol rates is increases and ultimate decreasing of pollution as E-scooter are Zero Emission Vehicle

III. METHODOLOGY

Retrofitting an IC engine scooter into a hybrid scooter involves the conversion of the existing internal combustion engine (ICE) system to a hybrid system, which combines an electric motor and battery with the existing ICE.

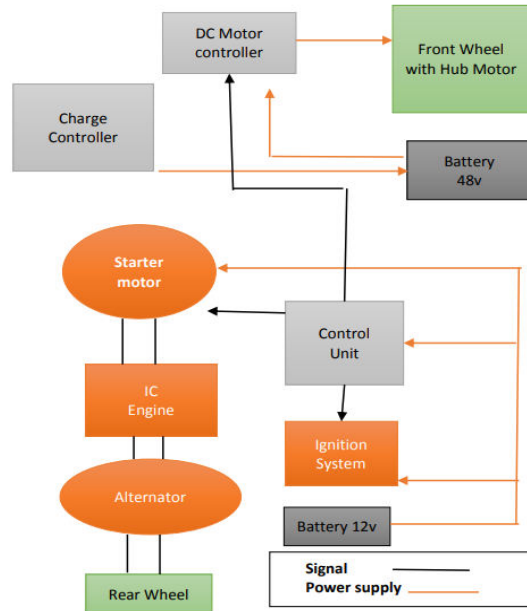


Figure1Block diagram

The above Fig.1 shows the block diagram of parallel hybrid type. This hybrid powertrain uses 1.2 kW driven front wheel and the rear wheel is driven by a conventional engine. Lead acid battery having a rating of 24 V, 9 Amp each are connected in series to deliver power to the motor. The batteries can be charged through an external electric source. The control strategy is developed such as both the wheels can drive the scooter individually or simultaneously depending on the requirements of the scooter. There are three different modes in which scooter can operate:

- Economy mode (propulsion using motor only)
- Power drive mode (propulsion using engine only)
- Hybrid mode (propulsion combining power from motor and engine)

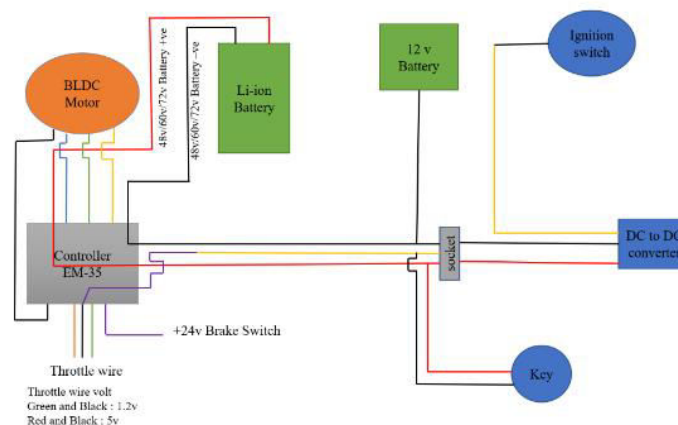


Figure2 Key switch diagram

The above diagram2 shows the connection diagram the conversion kit. It involves significant modifications to the vehicle's electrical system, including the addition of a key switch. This key switch controls the flow of electric power to the motor, and when turned on, the battery pack is connected to the controller, allowing the electric motor to power the scooter. The key switch diagram for a hybrid scooter conversion includes a battery pack, electric motor, controller, IC



engine, charging system, and the key switch itself. The controller regulates the flow of electric power from the battery pack to the electric motor, while the IC engine remains present but no longer the primary power source. The charging system includes a charging port and a charging circuit to recharge the battery pack from an external power source. Proper wiring of the key switch is essential to prevent safety hazards or damage to the electrical system.

IV. PRINCIPLE COMPONENTS

1. IC ENGINE SCOOTER



Figure 1 IC Engine scooter

A scooter is a motorcycle with an underbone or step-through frame, a seat, and a platform for the rider's feet, emphasizing comfort and fuel economy. Elements of scooter design were present in some of the earliest motorcycles.

2. DC TO DC CONVERTER



Figure 2 DC to DC converter

A DC to DC converter is an electronic device that converts a DC voltage from one level to another. It uses a high-frequency switching circuit to regulate the output voltage, resulting in higher efficiency, smaller size, and lower heat dissipation compared to linear regulators. It is used in various applications, including power supplies, electric vehicles, solar panels, and battery chargers.

Table 1 Converter characteristics

Input volt	48v-85v
Output volt	13.5v \pm 0.3v
Output current	10 AMP

3.ACCELERATOR CABLE



Figure 3 Accelerator cable

The accelerator cable in a hybrid electric scooter needs to be carefully designed and calibrated to ensure smooth and seamless transition between the fuel and electric power. It is also essential to ensure that the cable is well-maintained and periodically lubricated to prevent wear and tear, which can lead to poor performance or even failure. Overall, the accelerator cable is a crucial component of the hybrid electric scooter, which helps to deliver a smooth and efficient riding experience.

4.BLDC HUB MOTOR



Figure 4 BLDC hub motor

This is a basic hub motor with a power of 1.5Kw where this motor is fitted at the rear of the vehicle and controlled with the help of motor drive controller. It is a brushless motor. The size fitment of the wheel is 10inch. Unlike traditional brushed motors, BLDC hub motors have a longer lifespan and require less maintenance since there are no brushes to wear out.

Tab 2 Motor characteristics

Power	1.5 Kw
Weight	7 – 8 Kg
Wheel size	10 inches
Speed	40 - 60 Km/h
Torque	30 Nm



Maximum working temperature	80 C
Efficiency	85%

5.CONTROLLER



Figure 5 Controller

is a critical component of a hybrid scooter, as it regulates the flow of electrical power from the battery to the motor. It is essentially the brain of the electric scooter, controlling the speed and acceleration of the motor based on the rider's input. The controller typically consists of a printed circuit board (PCB), which contains various components, such as microprocessors, power transistors, and capacitors. These components work together to manage the flow of electrical power to the motor, ensuring that it operates at the correct voltage and current levels. The controller receives signals from the throttle, which the rider uses to control the scooter's speed.

Tab 3 Controller characteristics

Compatible voltage	48v / 60v
Rated current	35 A
Peak current	65 A
Maximum power	2.1 Kw
Type	Sine wave



6.LI-ION BATTERY



Figure 6 Li-ion battery

Is a type of rechargeable battery which uses the reversible reduction of lithium ions to store energy. This with a voltage capacity of 48 v with 15 Ah current. With this the motor can run up to 30 to 35 Km range in a single charge. It is a water proof with weight of 14Kg.

Tab 4 Battery characteristics

Voltage	48 v
Capacity	15 Ah
Range	30 -35 Km
Maximum working temperature	60 c
Maximum discharge current	20 Ah

IV. EXPERIMENTAL RESULTS

CALCULATION

Motor power required

To design an electric scooter with passenger of 250 kg and run at maximum speed of 45 km/hr

$$F_{total} = F_{rolling} + F_{gradient} + F_{aerodynamic\ drag}$$

Rolling resistance

Resistance between road and the tyre

$$F_{rolling} = Cr * m * a$$

Cr = co-efficient of rolling resistance

m = mass of vehicle in kg

a = acceleration due to gravity

$$Cr = 0.01, m = 250\ kg, a = 9.81\ m/s^2$$

For a normal load condition Cr will be 0.01

So,

$$F_{rolling} = (0.01) * (250) * (9.81) = 24.525\ N$$

Power required to overcome the rolling resistance



$$\begin{aligned}
 &= F_{\text{rolling}} * (\text{Velocity of vehicle in m/s}) \\
 &= 24.525 * 45 * (1000/3600) \\
 &= 360.5625 \text{ watts}
 \end{aligned}$$

Therefore $P \approx 300$ watts

F_{gradients} (Gradient resistance)

$$F_{\text{gradient}} = m * a * \sin \theta$$

Consider $\theta = 0$ when the vehicle travels at flat surface

$$\text{So } F_{\text{grad}} = 0 \text{ N}$$

Aerodynamic drag

$$F = 0.5 * \rho * V^2 * CA * Af$$

ρ = Density of air medium
 $= 1.23 \text{ kg/m}^3$

V = velocity of vehicle in m/s
 $V = 45 \text{ km/hr}$
 $= 12.51 \text{ m/s}$

CA = Coefficient of air resistance

Af = Frontal area of vehicle
 $= h * w * \text{adjusting value}$

(adjusting value for scooter is 70 %)

h = height upto rider with helmet
 $= 1630 \text{ mm}$

W = width of the handle bar
 $= 780 \text{ mm}$

$$\begin{aligned}
 Af &= (1.63 * 0.78) * 0.7 \\
 &= 0.89 \text{ m}^2
 \end{aligned}$$

$$\begin{aligned}
 F &= 0.5 * 1.23 * (12.51)^2 * (0.88)^2 * 0.89 \\
 &= 66 \text{ N}
 \end{aligned}$$

$$F \approx 66 \text{ N}$$

Power required to overcome this air resistance

$$\begin{aligned}
 &= 66 * (\text{velocity of vehicle in m/s}) \\
 &= 66 * 12.51 \\
 &= 825 \text{ watts}
 \end{aligned}$$

Total power required to overcome the resistance force will be equal to total power required to move the vehicle

Power needed for motor

$$\begin{aligned}
 &= 300 + 0 + 825 \\
 &= 1125 \text{ watts}
 \end{aligned}$$

$$\approx 1.2 \text{ kW}$$

Therefore, to design an electric scooter of 250 kg and to run at an average speed of 45 km/hr we need at least 1.2kW powered motor.

Table 5 Comparison of vehicle

Type	IC Engine	Electric	Hybrid
Vehicle cost (Rupees)	35000	33000	40000
Fuel cost 1 litre	100	10	110
Mileage 1 litre	47	35	82
Speed of vehicle	60	40	45



Figure 3.1 Experimental test rig

V. CONCLUSION

The project deals with the design and fabrication of Electric Scooter that promotes economical and eco-friendly means of transport for everyone. As the initial step, a literature survey on related systems and projects were conducted. Materials and components for the fabrication of the project were compared and selected. Retrofitting an IC engine scooter into a hybrid scooter offers several benefits, including reduced fuel consumption, lower emissions, and improved performance. While there are some potential disadvantages, such as higher upfront costs and limited range, the overall advantages make it a compelling option for those looking to reduce their environmental impact and operating costs. The vehicle is used to reduce the manual effort. This scooter has only three wheels, looks robust and lets you take it for a ride according to its design. Many systems can be improved in the future to optimize the manufacturing of the vehicle. Dynamo generators can be incorporated with the vehicle for charging while driving. Light weight carbon fibre can be used to reduce the overall weight of the vehicle and improves strength. This system can be efficiently used anywhere whether it is outdoor or indoor. This utilizes highly fuel-saving technology which is a major requirement of this era. We developed a branch and bound approach which is coupled with quick, effective bounds to optimize the Electric Scooter which serves the purpose of travelling and also use the non- renewable energy resources. On the whole, we are satisfied with our project.

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