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Design and Development of Smart Hybrid Two Wheeler

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ABSTRACT: India is a country with most number of commuting two wheelers in the world. A few run on petrol and some are driven by batteries. The vehicles which run on fuel have many limitations such as petrol is exhaustible and causes environmental pollution. The battery run vehicles are shallow on the performance side and are prone to malfunction. Through this project, we wish to design a system which runs both on engine and motor negating their individual limitations and maximizing their performance. This project is basically a fusion of two systems where the battery drives the vehicle at low speeds and passes the drive control to the petrol engine in case of reaching a set speed limit. The battery again takes over when the speed falls, which limits the usage of fuel at low speeds and hence increases the mileage. The design includes a petrol engine which drives the rear wheel and a battery connected to a motor which drives the front wheel. The system uses a relay circuit to shift the throttle control between the engine and the battery, and to switch the drive between engine and the battery under set conditions. The project aspires to become a comprehensive mechatronics system which shows significant increase in fuel economy there by making it more economic. This vehicle makes use of a smart Energy Management system. The system reduces environmental pollution momentarily by reducing the Carbon-di-oxide emission and consuming less fuel. The parts will be assembled on a scooter and the testing results will be tabulated before and after the assembly.

I. INTRODUCTION

A huge number of today's automobiles run on petroleum based products, and petroleum production is constantly decreasing and is estimated to be depleted in near future. Vehicles equipped with conventional internal combustion engines (ICE) have been in existence for over 100 years. With the increase of the world population, the demand for vehicles for personal transportation has increased dramatically in the past decade. This trend of increase will only intensify with the catching up of developing countries, such as China, India, and Mexico. The demand for oil has increased significantly. Moreover, current automobiles utilize only 25% of the energy released from petroleum and rest is wasted into the atmosphere, making the vehicle inefficient as well as creating a hazardous environment. Despite recent efforts to improve fuel efficiency and reduce toxic emissions in cars, emissions have continued to increase exponentially in the past two decades. For preservation of petrol for future and increasing the efficiency of vehicle an electric vehicle can be a major breakthrough. An electric vehicle is pollution free and is efficient at low speed conditions which are prevalent in high traffic areas. But battery charging is time consuming. However, it cannot provide high power required by drives during high speed conditions or in slopes of hilly areas. Petrol engine proves its efficiency at higher speeds in high ways and wastes a lot of energy in urban areas. Another problem associated with the ever-increasing use of personal vehicles is the emissions. The greenhouse effect, also known as global warming, is a serious issue that we have to face. There have been increased tensions in part of the world due to the energy crisis. Government agencies and organizations have developed more stringent standards for the fuel consumption and emissions. Nevertheless, with the ICE technology being matured over the past 100 years, although it will continue to improve with the aid of automotive electronic technology, it will mainly rely on alternative evolution approaches to significantly improve the fuel economy and reduce emissions. Battery-powered electric vehicles were one of the

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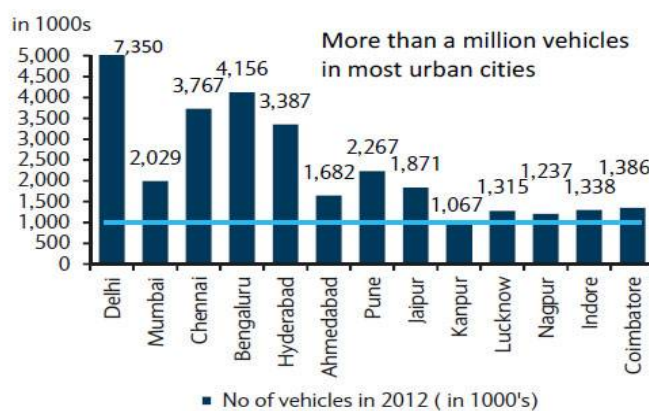
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solutions proposed to tackle the energy crisis and global warming. However, the high initial cost, short driving range, long charging (refuelling) time, and reduced passenger and cargo space have proved the limitation of battery-powered EVs. A hybrid vehicle solves these problems by combining the advantages of both the systems and uses both the power sources at their efficient conditions. The objective of this project aims at better utilization of fuel energy and reduces dependence on non-renewable resources using latest technology. The implementation involves development of Hybrid Electric Vehicle (HEV) that uses motor that is run by a battery as well as petrol engine for propulsion of vehicle. 'Hybrid vehicle' has been the most sought after concept in today's automobile industry. As a result of several researches and over many decades, hybrid vehicles were realized. Initially and majorly, the concept of hybrid was implemented in cars. The diesel-electric hybrid cars were revolutionary in the field. The focus slowly shifted towards the two wheelers. Now there is a grave need for implementation of hybrid in two wheelers. Two wheelers are popular means of transportation in Asia and play a very important role in providing personal transportation in most cities in Asia. Because of their small size and easy manoeuvrability, two wheelers help to alleviate traffic congestion and reduce energy consumption for the transportation of one or two passengers, compared with passenger cars.

In India, two wheelers serve as a primary transportation option that account for nearly two-third of the total vehicle population and consume more than 50% of petrol used. Statistics show that the two wheeler population in India has grown very rapidly in the last decade and has tripled during this period. At present, India has the second highest two wheeler density in the world. The expected high fuel consumption and emissions of two wheelers in urban areas need to receive more attention to improve the near-term sustainability of energy and urban air quality. Hybridization, especially in two wheelers, is the best approach to achieve better fuel economy in automobiles without actually compromising on performance. The advent of hybrid electric vehicles offers the capacity to improve fuel economy using an electric motor to reduce the fluctuating energy requirements of the internal-combustion engine at different load conditions and ever varying engine speed. Hybrid electric vehicle (HEV) technology has the potential to reduce urban emissions and overall petroleum consumption with proper implementation. A plug-in hybrid electric vehicle (PHEV) has the facility to plug-in to a standard electric outlet thereby displacing a significant portion of transportation petroleum consumption using electricity for portions of trips where using the IC engine is less efficient. A key benefit of plug-in hybrid technology is that the vehicle no longer depends on a single fuel source. A unique advantage of plug-in hybrid vehicles is their capability to integrate the transportation and the electric power generation sectors to improve the efficiency, fuel economy, and reliability of both systems.

More than a million vehicles in most of the leading developed cities in India



Source: MORTH, Barclays Research

1.1 Concept of Hybrid Electric Vehicle (HEV): A 'petrol-electric hybrid vehicle' is an automobile which relies not only on petrol but also on electric power source. In HEV, the battery alone provides power for low-speed driving conditions. During long highways or hill climbing, the petrol engine drives the vehicle solely. Hybrid electric vehicles

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comprise of an electric motor, battery as electric drive and an internal combustion engine driven on petrol. It is to achieve better fuel economy and reduce toxic emissions.

The HEV was developed to overcome the disadvantages of both ICE vehicles and the pure battery-powered electric vehicle. The HEV uses the on-board ICE to convert energy from the on-board gasoline or diesel to mechanical energy, which is used to drive the on-board electric motor, in the case of a series HEV, or to drive the wheels together with an electric motor, in the case of parallel or complex HEV. The on-board electric motor(s) serves as a device to optimize the efficiency of the ICE, as well as recover the kinetic energy during braking or coasting of the vehicle. The ICE can be stopped if the vehicle is at a stop, or if vehicle speed is lower than a pre-set threshold and the electric motor is used to drive the vehicle along. The ICE operation is optimized by adjusting the speed and torque of the engine. The electric motor uses the excess power of the engine to charge battery if the engine generates more power than the driver demands or to provide additional power to assist the driving if the engine cannot provide the power required by the driver. Due to the optimized operation of the ICE, the maintenance of the vehicle can be significantly reduced, such as oil changes, exhaust repairs, and brake replacement. In addition, the on-board electric motor provides more flexibility and controllability to the vehicle control.

It has great advantages over the previously used gasoline engine that is driven solely from gasoline. This hybrid combination makes the vehicle dynamic in nature and provides its owner a better fuel economy and lesser environmental impact over conventional automobiles.

II. DESIGN

The below figure is a schematic representation of basic design of the system. The block diagram shows the flow of control between the two systems and the display of various components present in the system. The system consists of a motor that is driven by the battery and an Internal Combustion Engine which runs on petrol. These two systems are integrated using the **Energy Control Mechanism (ECM)**. The vehicle starts from rest and is driven by the motor up to a certain set speed. Once the speed is reached, the ECM senses it and transfers the control to the engine. This enables the vehicle to be ridden in the optimum range of each system.

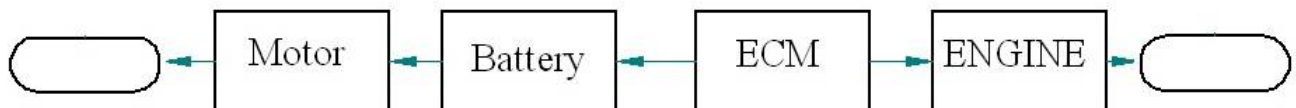


FIG 2.1 BLOCK DIAGRAM OF A HYBRID ELECTRIC VEHICLE.

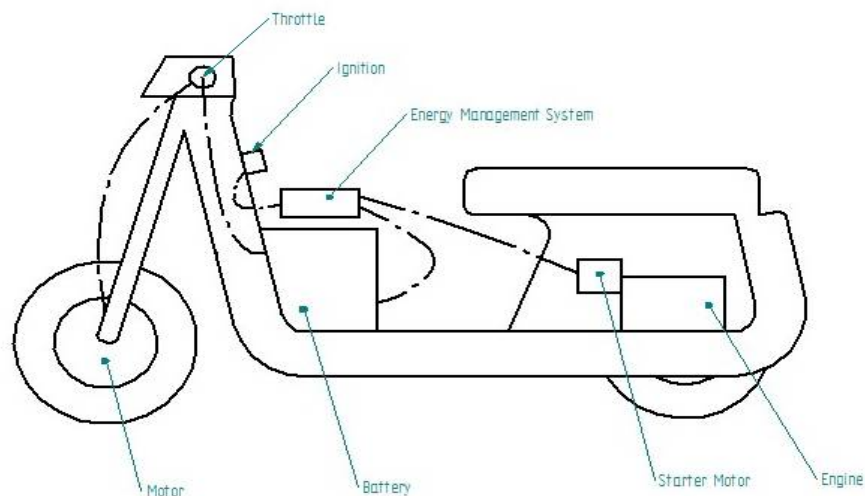


FIG 1.4: LAYOUT OF THE PROPOSED VEHICLE

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The above figure shows the layout and basic positioning of the parts in the system. The vehicle at lower speed act as front wheel drive and at high speed gets switched to rear wheel drive automatically. Components in the figure shows the attachment of tyre with the hub motor since the torque produced is sufficient enough to drive the vehicle. The axle of the motor is connected to the suspension; suspension is connected to the handle which is connected to the main chassis. A microcontroller powered up from battery, performs the switching from electric to internal combustion or vice versa as per the requirement. The system comprises of four batteries which are placed in front. Engine which is connected to the starter motor is in turn connected to the main chassis and seat is situated above the engine. CVT is connected to the crank shaft of the engine to avoid any shocks while switching and it makes the controlling simpler and easier.

- a) Vehicle: The Hybrid employs the frame, chassis engine and other structural components are adopted from a Scooty ES the image and specification of the same are as below.



FIG 2.1: PURCHASED VEHICLE

SPECIFICATIONS	
Engine Displacement	59.9 CC
Number Of Cylinders	1
Max Power	2.5 kW
Max Torque	4.5 Nm
Fuel Type	Petrol
Starter	Electric-Kick
Kerb weight	79.5 kg

TABLE 5.1: VEHICLE SPECIFICATIONS

- b) Electrical System : The Electrical System consists of the following components
- a. Battery: The battery is required to supply energy to run the vehicle through the Hub Motor. It is a combination of 4 batteries each of which are 12 V 24 Ah Lead Acid gel battery. The batteries weigh 8 kg.
 - b. Motor: The project employs a hub motor which is a 500W 1000 rpm Brushless Direct current hub motor. This is connected to the battery through an electronic speed controller that senses the position of the throttle runs the motor at the required speed.
- c) Electronic System: The electrical system is the stand out which decides between the energy sources. It consists of :
- a. Hall Effect Sensor: This sensor measures the Rotations and sends it to the Decision making board.
 - b. Arduino Uno: This is the essential Decision making board. This calculates the speed of the vehicle and decides whether to run on the battery or the engine.
 - c. Relay Switches: The relays act as the interface between the decision making circuit and the physical components.
- d) Throttle System: This system makes use of a combined throttle system which is used to throttle the vehicle in both ICE mode and Battery mode.

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III. WORKING

This system uses a hub motor driven by the batteries in the front and an IC engine in the rear and an Arduino which gets its input from the speed sensor circuit which continuously feeds the instantaneous speed of the vehicle. The Arduino is connected to a relay switch which performs the essential switching on the command of the relay. There are three relays which perform the switching for various controls of the vehicle. The specifics are as below:-

- Relay 1: The first relay is connected to the battery circuit and hence switches on and off the circuit when the need arises.
- Relay 2: The second relay is connected to the ignition circuit which turns on and off the engine.
- Relay 3: The relay three is connected to the starter circuit which triggers the starter motor when commanded by the Arduino.

There basically are three modes of operation which are selected by the toggle switch.

MODE 1: Battery mode

This mode is a battery only mode, i.e. the hub motor alone runs the vehicle at any speed, essentially, in this mode, and the vehicle can be considered an Electric vehicle. The battery mode is useful during low speed and beneficial in high traffic conditions. Also, the battery mode can be used when the fuel is low. During this mode the Arduino through the sends a high signal to the relay 1 due to which the battery circuit is on. The relays 1 and 3 are off.

MODE 2: Engine mode

Like the battery only mode, the entire motion of the vehicle is dependent on the IC engine alone. The self-starter motor is connected to one of the terminals of a 3-way switch and when it is switched to the engine mode, the engine starts as a result of starting of self-starter motor. In this mode the Arduino send a high signal to the relays 2 and 3(for 750 ms). This essentially cuts off the power to the hub motor and turns on the engine through the starter motor.

MODE 3: Automatic mode

This is the most important and efficient mode. This includes both the systems working in tandem. The vehicle by default starts in the battery mode. The Arduino board is programmed to cut off the battery and start the engine at a certain pre-set speed. At this speed the battery is off and the engine starts running. During this mode the Arduino essentially performs 2 tasks. Firstly, it senses and receives the signal from the Hall Effect sensor. Using this it measures the time interval between two consecutive rotations of the wheel and calculates the speed of the vehicle. Based on this speed it performs its second and most important function of decision making where it decides which source of energy would run the vehicle and shift spontaneously between the engine and the battery mode.

IV. RESULTS

After assembly of all the components the vehicle was tested as a whole for all the modes of the vehicle and the following results were obtained and are tabulated as follows:

a) Efficiency:

- The motor and the engine average efficiencies of the vehicle were tested individually and were compared with their corresponding maximum efficiencies.
- We can see an increase in the total efficiency of 40.8% in the Smart Hybrid system.

b) Energy Management system:

- An Energy Management system was developed successfully which can make decisions based on speed to obtain maximum mileage and reduce fuel emissions.

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c) Emission:

- The CO₂ emission in an IC engine is maximum in the speed range of 0kmph-20kmph, as the motor is being used in this range, the emissions are negligible.
- The emissions are least in the speed range of 20-40, and the vehicle majorly runs in this range, hence it significantly decreases the emissions.

d) Life:

- The lifecycle of both the systems is increased as the vehicle runs at their respective prescribed speed limit.

Type	Engine mileage (km/L)	Battery mileage (km/C)	Total mileage
Manual Hybrid	36	35	71
Smart Hybrid	50	50	100

IV. CONCLUSION

HEV is a vehicle that uses two sources of power- Battery and Petrol. A battery is used to run the hub motor on the front wheel and the IC engine fueled by petrol is used to run the rear wheel. The vehicle is equipped with three modes, battery only mode, engine only mode and an automatic mode. The vehicle runs only on one source in the first two modes respectively. In the third mode, the control shifts from one mode to another based on the preset speed condition. At low speeds, the motor is highly efficient and the engine's efficiency is low besides emitting a lot of hazardous substances and creating noise pollution while idling and in slow moving traffics. So the motor is used to propel the vehicle at low speeds. As the speed increases, the motor becomes inefficient and the engine's efficiency increases, hence the engine takes over at the higher speeds. Thus it is most efficient in urban areas mainly in high traffic where petrol engines are least efficient, reducing emission and fuel consumption which is high at low speeds.

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