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Review on Hybrid Electric Two Wheeler,

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Abstract: *India is a country with most number of commuting two wheelers in the world. Some are driven by petrol and some are driven by batteries. The vehicles which run on fuel have many limitations such as petrol demand is increasing day by day and it near to end 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 hybrid two wheeler 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 we drive the vehicle through battery drives at low speeds application and passes the drive control to the petrol engine in case of high speed application. 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 hub 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. The system reduces environmental pollution momentously by reducing the Carbon-di-oxide emission and consuming less fuel.*
Keywords– *Hybrid Two Wheeler, Battery, Hub Motor, Relay Circuit, Throttle Control*

I. Introduction

About 93 percent of today's vehicles are running on petroleum products, which are estimated to be depleted by 2050[1]. Moreover, current automobiles use only 25% of the energy comes out from petroleum and rest is wasted into the atmosphere [2].Despite recent efforts to improve fuel efficiency and decrease toxic emissions in vehicles, emissions have continued to increase steadily in the past two decades. For preservation of fuel for future and increasing the efficiency of vehicle an electric vehicle can be a major breakthrough. An electric vehicle is pollution free and is capable at low speed conditions mostly in high traffic areas. But battery charging is time consuming. Likewise, it cannot provide high power required by drives during high speed conditions or in slopes of mountainous areas. Fuel engine proves its efficiency at higher speeds in high ways and waste a lot of energy in urban areas. A hybrid electric vehicle solves these problems by combining the advantages of both the systems and uses both the power sources at their proficient conditions. The aim of this project is focus on better utilization of fuel energy and minimizes dependence on non-renewable resources using most recent technology. The implementation involves development of HEV that uses battery as well as gasoline power for propulsion of vehicle.

II. Concept Of Hybrid Electric Vehicle (Hev)

A ' hybrid vehicle' is an automobile which relies not only on petrol but also on electric power source. In HEV, the battery alone supply power for low-speed driving conditions. During long highways or hill climbing, the petrol engine drives the vehicle solely. Hybrid electric vehicles 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 minimize toxic emissions.

The hybrid electric vehicle was developed to overcome the drawbacks 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 fuel 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 difficult HEV. The on-board electric motor(s) serves as a tool 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 Internal combustion engine operation is optimized by adjusting the speed and torque of the engine. The electric motor uses the surplus power of the engine to charge battery if the engine generates extra power than the driver demands or to provide extra power to help 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.

III. Block Diagram Description

Parallel hybrid vehicle allowing both the combustion engine and the electric motor to propel the car. Fig.1 shows that the I.C. engine and motor operate in tandem. Generally the combustion engine operates as the primary means of propulsion and the electric motor acting as a backup or torque/power booster. The benefits of this are smaller batteries (less weight) and generally more efficient regenerative braking to both slow the car and capture energy while doing so. Another benefit is that it can simply be incorporated into existing vehicle models. Mainly hybrids on the road are of the parallel type.

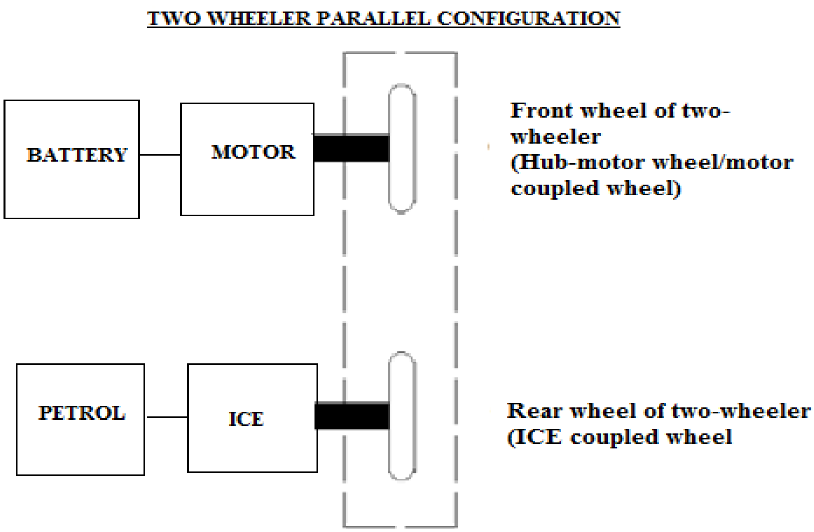

Fig. 1: Parallel hybrid

In a Parallel Hybrid vehicle human and motor power are mechanically coupled at the pedal drive train or at the rear wheel. Human and motor torques is combining together.Almost all manufactured HEV are of this type.

IV. Design Of Proposed Vehicle

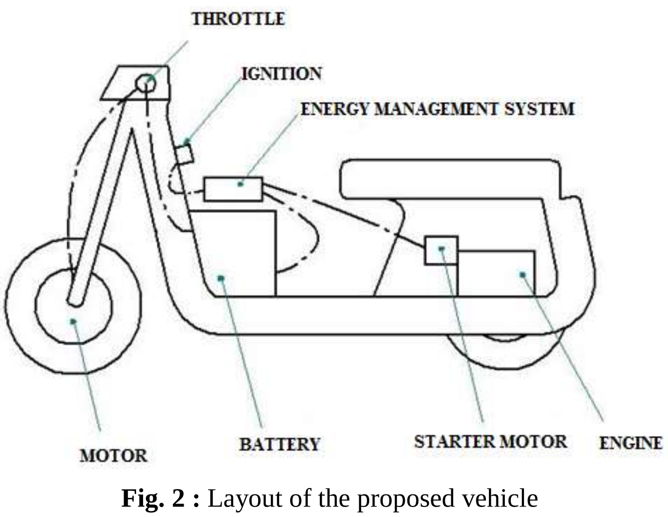

Fig. 2 : Layout of the proposed vehicle

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. Components in the figure shows the attachment of tire 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.

V. Component Description

The components used in this project are BLDC Hub Motor, DC Motor Controller, Batteries, Charging circuit, Ignition switch, Accelerator.

5.1 BLDC Motor

Brushless DC motor also known as electronically commutated motors are synchronous motors that are powered by a DC electric source via an integrated inverter which produces an alternating electric signal to drive the motor. In this manner, an alternating current, does not affect a sinusoidal waveform, but rather a bi-directional current with no effect on waveform. Additional sensors and electronics control the amplitude and waveform of the inverter output (and therefore the efficiency of the DC bus) and the frequency (i.e. rotor speed).The rotor part of a brush less motor is often a permanent magnet synchronous motor, but it can also be a switched or induction motor. Brush-less motors may be explained as stepper motors; however, the term stepper motor tends to be used for motors that are formulated specifically to be operated in a mode where they are smoothly stopped with the rotor in a defined angular position.

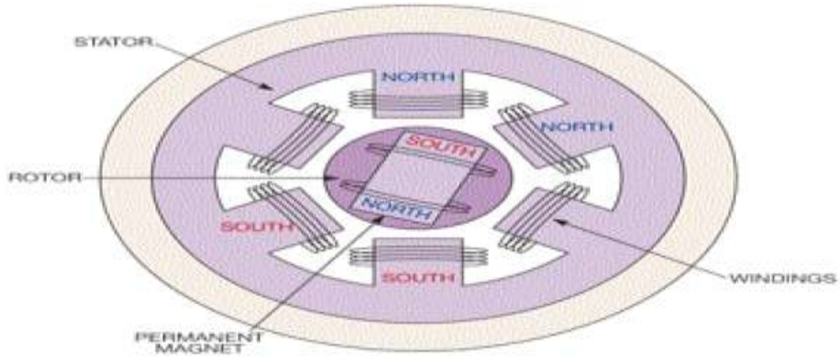

Fig. 3: BLDC motors have a motor with a permanent magnet contain north and south poles

Two key performance parameters of brushless DC motors are the motor constants Kv and Km (which are numerically equal in SI units).The four poles on the stator of a two-phase brushless motor.

Table1:Technical Specifications of hub motor

Sr.no.	Features	Description
1	Rated voltage(V)	48v
2	Rated power (W)	750 watt
3	Controller current limit (A)	25A
4	Rated speed (rpm)	3000 RPM
5	Max. torque (N-m)	4.78 N-M
6	Max. Power (W)	>750 watt

5.2 DC Controller

The controller connects the power source to the motor. It controls speed, direction of rotation, and optimizes energy conversion. While batteries produce constant voltages which decrease as they are used up, some controllers require a DC to DC converter to step down this variable voltage to the motor's expected constant operating voltage, but other controllers incorporate a DC-to-DC converter and can accept a changeable voltage. Converter efficiencies are typically greater than 90%.

The motor controller is being interfaced with the motor speed regulation. The speed varying throttle is being connected through the motor controller circuit. The motor used here is 48V, 750W, Ampere made hub motor. The controller for the motor is also Ampere made suitable for regulating the specified motor. The throttle is an ampere made throttle for speed control of the specified motor. The input to the motor is supplied by four Exide made Electra lead-acid batteries each of 12V, 26Ah through controller for testing purpose. Two independent propelling sources are being employed for determining total propulsion of the vehicle.

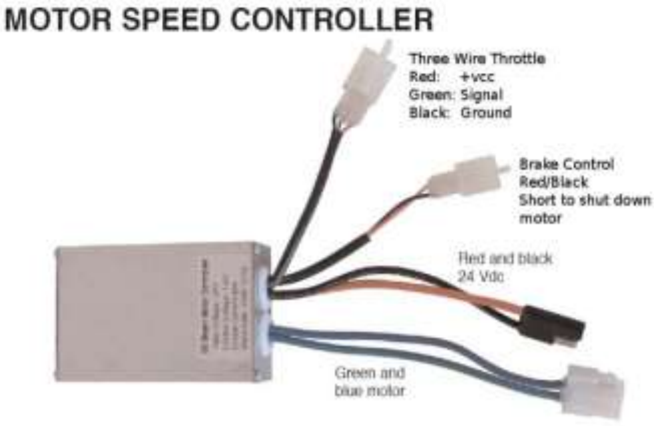

Fig. 4: DC controller

Table 2: Specifications of DC controller

Sr.no.	Features	Description
1	Rated Voltage (V)	48v
2	Rated Power (W)	750 watt
3	Rated Current (A)	25A
4	Efficiency (%)	95%
5	Under voltage protection	42v

5.3 Battery Storage

5.3.1 Lead Acid Battery:-

French physicist Gaston Planté invented the lead-acid battery in 1859 and is the oldest type of rechargeable battery. Although the energy-to-weight ratio is very low and the energy-to-volume ratio is low, its ability to supply high surge currents means that the cells have a relatively high power-to-weight ratio. These characteristic, with their low-cost, make it reliable for use in motor to provide the high current required by automobile starter motors.Since they are cheap compared to new technologies, lead acid batteries are widely used even if surge current is not important and other designs could provide higher densities of energy. Large-size lead-acid designs are commonly used for storage in backup power supplies in cell phone towers, high-availability settings like hospitals. For these roles, recent versions of the standard cell may be used to improve storage times and decrease maintenance requirements. Due to the freezing-point depression of the electrolyte, as the battery discharges and the concentration of sulfuric acid decreases, the electrolyte is more likely to freeze during winter weather when discharged. During discharge, H^+ produced at the negative plates and from the electrolyte solution moves to the positive plates where it is consumed, while HSO^{-}_{4} is consumed at both plates. The reverse occurs during charge. This movement can be by diffusion through the medium or by flow of a liquid electrolyte medium. Since the density is greater when the sulfuric acid concentration is higher, the liquid will tend to flow by convection.

Fig. 5: Lead acid battery

Table 3: Specifications of Lead acid battery

Rechargeable batteries specification	
No. of batteries	4
Current	33A
Voltage	12V

5.4 Charging Circuit

These Chargers are designed to fulfill all kind of power requirements of Electric Bike .Battery charging which operates in AC input range (170 - 300VAC) and to withstand the adverse Indian power conditions. These are designed with high - frequency switching technology, which makes the product extremely reliable, cost - effective and compact in size and weight. When the charge level in the charge indicator shows less, then the Engine is switched on mechanically. The power developed from the engine generates electricity through the BLDC motor and charges the batteries through the Charging circuit.

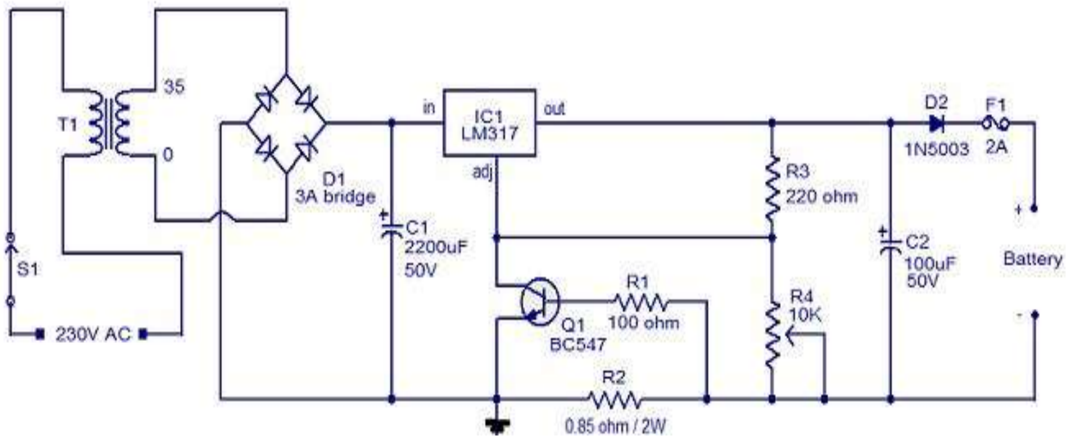

Fig. 6: Charging circuit diagram

VI. Braking System

Brakes are used to decrease the speed of motors. We know that there are different types of motors available (DC motors, induction motors, single - phase motors, etc.) and the specific characteristics and properties of these motors differ, so these braking methods also differ from each other. But we can divide braking in to three parts mainly, which are applicable for almost every type of motors During braking, the motor fields are linkedacross either the main traction generator (diesel-electric locomotive, hybrid electric vehicle) or the supply (electric vehicle) and the motor armatures are connected across braking grids (rheostat) or the supply (regenerative). The rolling wheels rotate the motor armatures and when the motor fields are excited, the motors act as generators.

6.1 Types of Braking
6.1.1 Dynamic Braking.
6.1.2 Regenerative Breaking
6.1.1 Dynamic braking

Dynamic braking is the use of the electric motors of a vehicle as generators when slowing. It is termed rheostat if the generated electrical power is transfer as heat in brake grid resistors, and regenerative if the power is back to the supply line. Dynamic braking lowers the wear of friction-based braking components, and additionally regeneration reduces energy consumption. During dynamic braking, the traction motors, which are now acting as generators, are connected to the braking grids of large resistors which put a large load on the electrical circuit. The generator circuit is loaded down with resistance; it causes the generators to resist rotation, thus de-accelerating the train. The traction motors can slow the train to approximately 5 mph (8 km / h) by changing the amount of excitement in the traction motor fields and the amount of resistance fed to the circuit by the resistor grids (for a direct current ,transmission, system; for an alternating current ,transmission, system, the traction motors can slow the train to almost 0 mph (0 km / h)).

Locomotives with a direct current ,transmission, system always use series-wound traction motors, since these motors produce their maximum tractive effort at ,stall, or zero mph, so that almost any train can be started easily. However, this method releases all energy as heat in the engine itself and cannot therefore be used in anything other than intermittent low-power applications due to cooling constraints.

6.1.2 Regenerative Braking

Regenerative braking takes place whenever the speed of the motor increases the synchronous speed. These methods called regenerative braking because here the motor works as generator and supply itself is given power from the load. The main principle for regenerative braking is that the rotor has to rotate at a speed greater than synchronous speed, only then the motor will act as a generator and the direction of current flow through the circuit and direction of the torque opposite and braking takes place. The only drawback of this type of braking is that the motor has to run at super synchronous speed which may damage the motor mechanically and electrically, but regenerative braking can be done at sub synchronous speed if the variable frequency source is present.

VII. 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 two 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. There basically are two 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 Arduinothrough 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

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 and3 (for 750 ms). This essentially cuts off the power to the hub motor and turns on the engine through the starter motor.

VIII. Result

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:

i) 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 Hybrid system

ii) Emission:

- The CO_2emission 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.

IX. Conclusion

HEV is a vehicle that uses two sources of power- petrol and battery. For low power application battery drive is used whereas for high power application where power requirement is very high petrol engine is used. Petrol drive is most efficient at high speed drive. Thus HEV's two operating modes are therefore at their maximum efficiency.But in petrol engine low speed operation is not efficient. Its high speed mode is only efficient. Therefore, it gives higher mileage than normal vehicle.

As this hybrid vehicle emits less emission than normal vehicle it plays an important role for decreasing pollution to certain extent without compromising with efficiency. Thus it is most efficient in urban areas mainly in high traffic where petrol engines are least efficient as the energy from petrol is being wasted away and creates pollution.

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