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Two drive modes for the vehicle

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Abstract— Looking at the current fuel price hike, private transport is progressively getting to be unviable for the normal man. Fuel consumption of bikes increases when you are driving on a slope and in substantial rush hour traffic where you have to switch the gear over and over again, also driving the bike in the lower gear. In the event that you change over to battery mode in these street conditions, this issue can be survived. The driver will have the choice of utilizing either battery-run front wheel drive or engine run rear wheel drive. When running on a non-conventional fuel (electricity in this case) we benefit our environment through less pollution and zero noise.
To achieve this, we used a trial and error method to make a bar link that would sustain the load of the hub motor mounted on the front wheel. To control the speed of the hub motor, we fit the controller just above the headlight assembly. We also provided a switch in the boot space to turn on the electric drive mode also mounted the batteries just below the footrest. To accelerate the vehicle we fitted the accelerator, which is connected to the controller, on the left side of the bar handle. We made some demo runs of the vehicle, calculated the data and proved that two drive modes for the vehicle are more efficient and environmentally friendly than a normal gasoline powered vehicle.

Index Terms— Brushless DC motor, Electric Hub motor, Two Drive Mode, Hybrid Two-wheeler, Motor assis, Motor Controller, Non-conventional fuel.

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1 Introduction

Around 89% of today's automobiles run on petroleum-based product, which are estimated to be depleted by 2050. Moreover, current automobiles utilize only 25% of the energy released from petroleum and rest is wasted into the atmosphere. Despite recent efforts to improve fuel efficiency and reduce toxic emissions in the gasoline-powered vehicles, emissions have continued to increase steadily in the past two decades. For preservation of gasoline 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 mainly in high traffic areas. But battery charging is time consuming. Moreover, it cannot provide high power required by drives during high speed conditions or in slopes of hilly areas. Gasoline engine proves its efficiency at higher speeds in highways and waste a lot of energy in urban areas. 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 research aims at better utilization of fuel energy and reduces dependence on non-renewable resources using latest technology. Thus, we have developed two drive modes for the two-wheeler that uses battery as well as gasoline power for the propulsion of vehicle.

We have taken into consideration the goal of the International Council on Clean Transportation (ICCT) to dramatically improve the environmental performance and efficiency of personal, public and goods transportation in order to protect and improve public health, the environment, and quality of life.

2 History

The 1915 Dual Power made by the Woods Motor Vehicle electric car maker had a four-cylinder internal combustion engine and an electric motor. Below 15 mph (25 km/h) the electric motor alone drove the vehicle and above this speed the "main" engine cut in to take the car up to its 35 mph (55 km/h) top speed. About 600 were made up to 1918.

There have also been air engine hybrids where a small petrol engine powered a compressor. Several types of air engines also increased the range between fill-ups with up to 60% by absorbing ambient heat from its surroundings.

In 1959 the development of the first transistor-based electric car—the Henney Kilowatt—heralded the development of the electronic speed control that paved the way for modern hybrid electric cars. The Henney Kilowatt was the first modern production electric vehicle and was developed by a cooperative effort between National Union Electric Company, Henney Coachworks, Renault, and the Eureka Williams Company. Although sales of the Kilowatt were dismal, the development of the Kilowatt served was a historical "who's who" of electric propulsion technology.

A more recent working prototype of the electric-hybrid vehicle was built by Victor Wouk. Wouk installed a prototype electric-hybrid drive train into a 1972 Buick Skylark provided by GM for the 1970 Federal Clean Car Incentive Program, but the program was killed by the EPA in 1976 while Eric Stork, the head of the EPA at the time, was accused of a prejudicial cover up. Since then, hobbyists have continued to build hybrids, but none was put into mass production by a major manufacturer until the waning years of the twentieth century.

The regenerative-braking hybrid, the core design concept of most production hybrids, was developed by Electrical Engineer David Arthurs around 1978 using off-the shelf components and an Opel GT. However, the voltage controller to link the batteries, motor (a jet-engine starter motor), and DC generator was Mr. Arthurs'. The vehicle exhibited ~75 mpg fuel efficiency and plans for it (as well as somewhat updated versions) are still available through the Mother Earth News web site. The Mother Earth News' own 1980 version claimed nearly 84 mpg.

The Bill Clinton administration initiated the Partnership for a New Generation of Vehicles (PNGV) program in September 29, 1993 that involved Chrysler, Ford, General Motors, USCAR, the DoE, and other various governmental agencies to engineer the next efficient and clean vehicle. The NRC cited automakers' moves to produce hybrid electric vehicles as evidence that technologies developed under PNGV were being rapidly adopted on production lines, as called for under Goal 2. Based on information received from automakers, NRC reviewers questioned whether the "Big Three" would be able to move from the concept phase to cost effective, pre-production prototype vehicles by 2004, as set out in Goal 3.

The program was replaced by the hydrogen focused FreedomCAR initiative of George W. Bush's administration in 2001. The focus of the FreedomCAR initiative being to fund research too high risk for the private sector to engage in with the long-term goal of developing emission / petroleum free vehicles.

In the intervening period, the widest use of hybrid technology was actually in diesel-electric locomotives. It is also used in diesel-electric submarines, which operate in essentially the same manner as hybrid electric cars. However, in this case the goal was to allow operation underwater without consuming large amounts of oxygen, rather than economizing on fuel. Since then, many submarines have moved to nuclear power, which can operate underwater indefinitely, though a number of nations continue to rely on diesel-electric fleets.

Toyota Prius has been in high demand since its introduction. Newer designs have more conventional appearance and are less expensive, often appearing and performing identically to their non-hybrid counterparts while delivering 50% better fuel efficiency. The Honda Civic Hybrid appears identical to the non-hybrid version, for instance, but delivers about 50 US mpg (4.7 L/100km). The redesigned 2004 Toyota Prius improved passenger room, cargo area, and power output, while increasing energy efficiency and reducing emissions. The Honda Insight, while not matching the demand of the Prius, is still being produced and has a devoted base of owners. Honda has also released a hybrid version of the Accord.

2005 saw the first hybrid sport utility vehicle (SUV) released, Ford Motor Company's Ford Escape Hybrid. Toyota and Ford entered into a licensing agreement in March 2004 allowing Ford to use 20 patents from Toyota related to hybrid technology, although Ford's engine was independently designed and built. In exchange for the hybrid licences, Ford licensed patents involving their European diesel engines to Toyota. Toyota announced model year 2005 hybrid versions of the Toyota Highlander and Lexus RX 400h with 4WD-i which uses a rear electric motor to power the rear wheels negating the need for a differential. Toyota also plans to add hybrid drive trains to every model it sells in the coming decade.

For 2007 Lexus offers a hybrid version of their GS sport sedan dubbed the GS450h with "well in excess of 300hp". The 2007 Camry Hybrid has been announced and is slated to launch in late spring as a 2007 model. It will be built in Kentucky, USA. Also, Nissan announced the release of the Altima hybrid (technology supplied by Toyota) around 2007.

3 Current Status

A huge majority of the worldwide Electric Two-Wheeler (ETW) market — 95.8% — is concentrated in China. The ETW market in Japan, Europe, and more recently, India, is small but growing. The market is 1.4% in Japan, 1.5% in Europe, 0.3% in India. The market is only 0.8% in the United States and 0.2% in Southeast Asia.

After China, the next largest ETW market is Japan, with annual sales of 270,000 bikes/yr in 2006 and 13% average annual growth since 2000. Pedelecs are the dominant type of ETW. Most pedelec ETWs use Ni-MH or Li-ion batteries. Battery capacity ranges from 0.2 to 0.6 kWh, motor sizes range from 150 to 250 W, and prices range from $700 to $2,000. In Europe, the market was estimated at 190,000 bikes/yr in 2006. Electric bikes in Europe are also mainly pedelec style. Sales in the Netherlands are the greatest because of its extensive bicycle infrastructure and deep-rooted biking culture. Germany and Belgium are the next largest markets for pedelecs.

India's electric bike market is small, but forecasts for growth are optimistic. In other developing countries throughout Southeast Asia, like Thailand, Vietnam, and Indonesia, where two-wheelers are the dominant form of transportation, ETWs have not gained a significant market share. This trend may be attributed to the fact that valve-regulated lead-acid (VRLA) battery performance (i.e., range and lifetime) degrades quickly in areas where temperatures are very high (or very low) throughout the year. Gasoline-powered motorbikes are the dominant mode in the larger cities of these countries.

4 Working of Two Drive Modes For The Vehicle

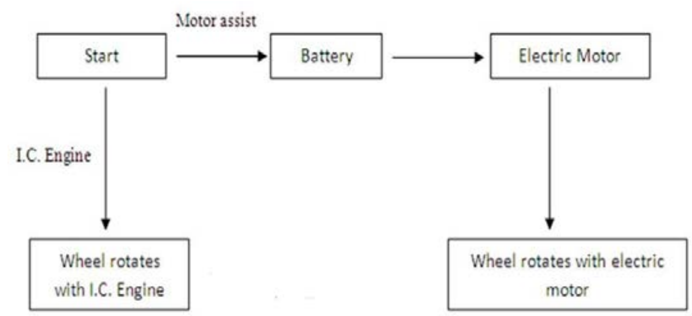

Fig. 1. Line diagram of the Hybrid Two-Wheeler

In this vehicle, the battery alone provides power for low-speed driving conditions. During long highways or hill climbing, the gasoline engine drives the vehicle solely. Hybrid electric vehicles comprise of an electric motor, controller, battery as electric drive and an internal combustion engine with transmission connected as gasoline-based drive.

The hub motor is a conventional DC motor. The rotor is outside the stator with the permanent magnets mounted on inside. The stator is mounted and fixed onto the axle and the hub will be made to rotate by alternating currents supplied through batteries. Hub motor generates high torque at low speed.

The motor controller is an important component of the system. It is essential to control the amount of power supplied and to drive the Brushless DC hub motor. The controller converts the DC voltage from battery to an alternating voltage with variable amplitude and frequency that drive the hub motor at different speeds.

The maximum speed of a vehicle is 30 kmph. It is required to vary the speed depending upon the road conditions & traffic. Therefore, an accelerator or a throttle is necessary. Throttle allows us to drive the motor from zero speed to full speed. The throttle is fitted on left side of the handle bar and is connected to controller.

The basic design consists of a dc power source battery. The battery is connected to controller that is fed to a Brushless DC motor that works on AC. The motor is attached to the front wheel of the two-wheeler vehicle. As the motor rotates the attached wheel rotates too, thus, leading to vehicle motion. At low speeds this mode of propulsion is used. The next phase consists of an internal combustion engine that moves the piston continuously. This is connected to the transmission and thus, the vehicle moves.

All the above information regarding each and every component explains about the basic principle of working of two drive modes of the vehicle.

5 Fabrication

We fabricated the vehicle which consist of assembly of components i.e. hub motor, battery, motor controller and accelerator.

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5.1 Hub Motor

For this research we used the brushless DC motor rather than the brushed DC motor, because brushless DC motors are 85-90% efficient, whereas brushed DC motors are 75-80% efficient. Selected specifications for the hub motor -
Rated power of the hub motor – 750W,
Maximum RPM – 150

Fig. 2. Side view of the hub motor fitted on the front wheel of the vehicle

Ordinary electric motors use a mechanical device called a commutator and two contacts called carbon brushes to reverse the electric periodically and ensure the axle keeps turning in the same direction, but brushless DC motors have half a dozen or more separate coils and they replace the commutator and brushes with an electronic circuit. The circuit switches the power on and off in the coil in turn creating forces in each one that make the motor spin. Since the brushes of the brushed DC motors press against the axle of a normal motor, they introduce friction; slow it down, and waste energy. That's why brushless motor are often more efficient, especially at low speed. Getting rid of the brushes also saves the money.

To fit the hub motor on the front wheel, we developed a bar link using trail and error method on the lathe machine to match dimensions of the hub motor as shown in the fig. 2.

5.2 Battery

Compared with ordinary lead-acid cells, sealed batteries offer several advantages. The battery can be mounted in any position, since the valves only operate on over pressure faults. Since the battery system is designed to be recombinant and eliminate the emission of gases on overcharge; room ventilation requirements are reduced and no acid fume is emitted during normal operation. The volume of free electrolyte that could be released on damage to the case or venting is very small. There is no need (nor possibility) to check the level of electrolyte or to top up water lost due to electrolysis, reducing inspection and maintenance compared to Ordinary batteries, sealed batteries are more sensitive to high temperature environments and more vulnerable to thermal run-away during abusive charging condition. Following are the specifications of the batteries we used to achieve second drive mode for the vehicle:
Battery manufacturer – iPower
Nominal voltage – 12V
Nominal capacity – 24Ah
Dimensions - 150x100x80mm

5.3 Motor Controller

The motor controller is an important component of the system. It is essential to control the amount of power supplied and to drive the brushless DC hub motor. The controller converts the DC voltage from battery to an alternating voltage with variable amplitude and frequency that drive the hub motor at different speeds.

Fig. 3. Motor controller

To drive and control the brushless DC motor, the use of a motor controller is implemented. The motor controller is an essential device for any motor driven device. The motor controller is analogous to the human brain, processing information and feeding it back to the end user. Of course, the applications of a motor controller vary based on the task that it will be performing. One of the simplest applications is a basic switch to supply power to the motor, thus making the motor run. As one utilizes more features in the motor, the complexity of the motor controller increases. To drive the brushless DC motor, the motor controller sends rectangular/trapezoidal Voltage stokes that are coupled with the position of the rotor. The inputs to the controller include the speed and current signals that are supplied by the throttle. The DC power supply feeds power to the motor controller, which then distributes the voltage and current necessary to drive the brushless DC motor. The Hall Effect sensors provide the feedback needed for the motor to know the position of the rotor and to tell it when to supply the voltage stoke to the different phases of the brushless DC motor.

We fitted this controller on the front side of the vehicle just above the headlight assembly as shown in the fig. 4.

Fig. 4. Front view of the Hybrid Two-wheeler showing the assembly of the controller.

5.4 Accelerator

As we used the brushless DC Motor, it has separate speed control kit which is used to control the speed of the motor. We assembled the accelator on the left side of the handle so that dirver can easily vary the speed of the motor. The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. The controller may or may not actually measure the speed of the motor. If it does, it is called a Feedback Speed Controller or Closed Loop Speed Controller, if not it is called an Open Loop Speed Controller. Feedback speed control is better, but more complicated, and may not be required.

5.5 Summary

The components which we used or the vehicle are listed above. The front wheel is being propelled by the hub motor which is powered by the batteries connected in series and the rear wheel is powered by gasoline, i.e., the vehicle includes a single cylinder, air cooled internal combustion engine and a brushless DC motor based on electric power drive, used for hybrid powering of the vehicle. Also, we provided the control switch inside the boot space to switch on the power supply to the hub motor which is fitted in the front wheel.

6 Selected Vehicle

As in our research, the bike takes the total load of batteries, hub motor and rider's weight. Also, it is required to provide arrangement for installing battery on the bike. By considering all the above conditions we selected Honda Dio (100cc) so that it can carry load as mentioned above and also provision of the battery arrangement is possible. The load carrying capacity is 245 kg (including rider's weight). The weight of Honda Dio (100cc) bike is 105 kg. In other types of motorcycle, the frame construction is rigid and compact so there is unnecessary increase in weight and also sufficient place is not available for mounting of batteries, so Honda motorcycle is taken to complete above requirement. Also, difficulty arises in the mounting of motor in the front wheel due to improper dimensions of spokes in various motorcycles. This motor mounting is quite simple in Honda Dio (100cc) motorcycle.

7 Collected Data

TABLE 1
EXPERIMENTAL ATTRIBUTES

Attributes	Gasoline powered vehicle	Electric scooter	Hybrid vehicle
Fuel/Electricity cost (in Rs/Km)	2.2	0.25	0.9-0.11
Maintenance cost(Rs/15000Km)	4,500	6,800	7,200
Top Speed (Km/hr)	80	45	40 - on the electric mode 68 - on the gasoline power mode
Range (full tank/fully charged) (in Km)	175-190	70-80	230-240
Acceleration (0-30 Km/hr in XX sec)	04	06	07 – on the electric mode 05 – on the gasoline power mode

8 Conclusions

The development of the two drive mode vehicle is succefully completed that uses two different sources of power - gasoline and electric. For low power application battery drive is used whereas for high power application where power requirement is very high gasoline engine is used. Therfore, the range of vehicle is more than a normal gasoline powered vehicle. As this hybrid vehicle emits 0% emission when driven on the electric mode, it plays an important role for reducing pollution to certain extent without compromising with efficiency. It is most efficient in urban areas mainly in high traffic where gasoline engines are least efficient as the energy from gasoline is being wasted away and creates pollution. Thus two drive modes for the vehicle maintains the right balance between fuel consumption and pollution control.

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