Development of a hybrid electric vehicle engineering essay

The term HYBRID VEHICLE refers to a vehicle which uses two or more distinct power sources of energy to move the vehicle. The term commonly refers to HYBRID ELECTRIC VEHICLES (HEVs), which is a combination of an internal combustion engine and one or more Electric motors.

The intention of the presence of electric powertrain is intended for either improving the fuel economy or better performance.

1. 1 History of Hybrid Electric Cars

The seeds for the invention of Hybrid Electric Vehicles were laid a century ago i. e., in 1900. The first hybrid electric vehicle, Mixte was developed in 1900 at Lohner Coach Factory by Ferdinand Porsche. This is a 4WD series-hybrid version, includes a pair of generators driven by 2. 5 hp Daimler IC engines to extend its operating range ad could travel nearly 40miles on battery itself and was presented in Paris Auto Show in 1901. Mixte used gasoline engine powering a generator, this in turn powers up electric hub motor, and reached a speed of 50 kmph and a power of 5. 22 kW in 20 minutes.

Knight neftal produced a hybrid racing car in 1902. In 1905, H. Piper filed a patent for hybrid vehicle in US. In 1915 Dual Power, Woods Motor Vehicle electric car maker had a four cylinder IC engine and an electric motor. This car ran up to a speed of 24kmph on the electric motor alone, drawing the power from battery and after this speed, the IC engine took the car up to its 56kmph which was its top speed.

Later in 1915, a Canadian company produced the first car for sale. Woods Motor Vehicle company in Chicago released the first gasoline-electric hybrid car in 1917. the hybrid was a failure commercially, proving to be too slow for its price, and its difficulty to service.

The working prototype that is being used in most recent HEV was designed by Victor Wouk. His work on the HEVs in 1960s and 1970s earned him the title as " The Godfather of the Hybrid". Wouk installed a hybrid drive train having 16 KW electric motor into the, Buick Skylark provided by GM.

The Regenerative braking system, an important production concept for most of the HEVs was designed by David Arthurs in 1978 and used for the first time on Opel GT. The vehicle exhibited a fuel efficiency of 3. 1L/100km. Audi launched its first edition of Audi Duo, an experimental vehicle in 1989. It is a plug-in parallel hybrid with 9. 4 KW, Siemens electric motor and a Ni-Cd battery to supply energy to the motor which drive the rear wheels.

Esparante GTR-Q9 was the first petrol engine to take part in the race at Le Mans. Later, the car finished second in class at Petit Le Mans same year, i. e., in 1998.

Hybrid technology became familiar within the automobile industry in the late 1990s. All the automobile companies came to know about the social awareness of the customer, and then the mass production of the hybrid electric vehicles was started. The first of that kind is Toyota Prius in Japan, Honda Insight launched in 1999 in United States and Japan.

Now, all the leading automobile manufacturers like Jaguar, Ford, Lexus, and Peugeot were on to the production of the hybrid electric vehicles. This may lead to a revolution in the automobile industry in near future.

Briefing the Technologies Being Used in HEVs

These days, many research laboratories and firms are working on the development of hybrid electric vehicles. These bodies are recruiting the individuals from all technical backgrounds such as mechanical, automotive, electrical, electronics. So that, they can concentrate on each and every aspect of the vehicle, that can lead to the development of the vehicle irrespective of its technical aspects.

For e. g., NREL (National Renewable Energy Laboratory) is one of the kind of researching bodies, actively researching on the various aspects of fuel cells and vehicles that run using the power generated from the fuel cells. Fuel cell vehicles are much likely as of hybrid vehicles with diesel or petrol engines.

Modern HEVs are using many technologies which can improve the efficiency of the vehicle like Regenerative braking. This converts kinetic energy of the vehicle into electrical energy, instead of wasting it in the form of heat energy as like in conventional braking systems. Some HEVs use IC engines to generate electricity like an electrical generator, either to recharge the batteries or to empower the electric drive motors directly. Many HEVs are reducing the emissions at idle by stopping the IC engine and restarting when it is needed, this is known as start-stop system. External torque will be applied to the differentials when the electric powertrain is acting, which leads to the better performance of the HE vehicle.

Components of a Hybrid Electric vehicle

The structure of a Hybrid Electric Vehicle is much likely as that of an ordinary gasoline powered vehicle. The distinguishing factor is that a hybrid car will have one or more electric motors alongside which can improve gas mileage.

Note: In the case of Toyota Prius, car runs solely by electricity when driven under a speed of 30 Mph.

Figure : Structure of a basic Hybrid Electric Vehicle

1. 3. 1 Gasoline Engine

The gasoline engine in a hybrid electric car is like as that of an ordinary internal combustion engine. However, the engine is smaller comparatively and uses advanced technologies which can result in reducing emission and more efficiency.

1. 3. 2 Fuel Tank

The fuel tank of the hybrid electric vehicle acts as the fuel storage device for IC engine. Batteries can also be called as a fuel tank in the case of hybrid electric vehicles, as it stores the electricity produced and supplies when needed to the electric motor.

1. 3. 3 Electric Motor

The electric motor in a hybrid electric vehicle is very small and essential component to make it a hybrid. Day to day advance in electronics allows electric motor to act as a motor as well as a generator.

For e. g. it draws energy from the battery to accelerate the vehicle, when needed. But, while acting as a generator, it slows down the car and returns the energy back into the batteries.

1. 3. 4 Batteries

The batteries in the hybrid electric vehicle are the devices meant to store the energy which is needed for the electric motor. Unlike, the gasoline in the fuel tank, only power the gasoline engine, the electric motor of a hybrid electric vehicle can charge the batteries as well as draw energy from them.

1. 3. 5 Transmission

The transmission in a hybrid electric vehicle performs the same basic function as a transmission that of a conventional car.

Generator

The generator is much similar to electric motor, but it can only produce electric power. Generator is mostly used in the series hybrid electric cars.

1. 4Available power sources for Hybrid vehicle

The available sources of energy includes the following

Rechargeable Energy Resource System, RESS

Petrol or Diesel

Hydrogen

Compressed Air

Liquid Nitrogen

Electricity

Solar Energy

Rechargeable energy resource system (RESS)

A Rechargeable energy resource system or RESS is a system which stores energy to deliver power and is rechargeable. This can be done by using a battery. There are six types of batteries that are presently being used as a source, for the production of energy in Hybrid electric vehicles. Those are lead-acid, nickel-metal hydride, nickel-cadmium, lithium ion, zinc-air and flywheels.

Petrol or Diesel

Petrol is being vastly used as fuel in automotives, due to its high calorific value and more efficiency of the petrol cycle (Otto cycle) and low emission rate compared to most of the other alternative fuels and its abundance. The thermodynamic cycle involved in the petrol engines is called, Otto cycle or four stroke cycle.

Diesel is one of the best alternative fuels to petrol that can be used in automotives. The efficiency of the diesel engine is also good and the emission rate is a bit higher when compared to the petrol engine. The thermodynamic cycle that is used in the diesel engine is called Rankine's cycle

Hydrogen

Hydrogen can be used as an alternative fuel, as an onboard fuel for motive power to the vehicle. This can be used as a fuel in any automotive which

uses hydrogen in a similar fashion, as of in aircraft. The power plant of the vehicle converts the chemical energy of hydrogen into mechanical energy, this will be done either by burning the hydrogen in internal combustion engine, or by reacting hydrogen with oxygen in a fuel cell to run electric motors.

1. 4. 4 Compressed air

Compressed air can be used as a fuel in engines which are pneumatic actuators, which can create a useful work by expanding compressed air. This is being used from the past two centuries, ranging from hand held turbines to several hundred horsepower. Some of them rely on turbines, others on pistons and cylinders. The engine that works using compressed air as a fuel is also called as Air-Hybrid Engine.

Liquid Nitrogen

Liquid nitrogen can be used an alternative fuel to liquid hydrogen. The engine extracts heat from the ambient air which will be used for heating the liquid nitrogen in the heat exchanger and using the resulting pressurised gas to operate the rotary engine.

This can also be incorporated in hybrid vehicle systems, fuel tanks to recharge the batteries and the resulting in battery electric propulsion. This system is called Hybrid liquid nitrogen-electric propulsion. Moreover, regenerative braking system can also used in conjunction with this system.

Electricity

Electricity is being used as a fuel in automobiles since long time back. These cars run by drawing electricity from the battery to run the motor which in turn, runs the piston in the cylinder generating the mechanical energy which can move the car. The cars which run by using only the electric source are called plug-in electric cars. As these cars don't have any alternate source of energy other than battery, these needs to be charged time to time and hence called as plug-in electric vehicle. By adopting the electricity as an alternative source to the hybrid vehicle, the vehicle is called Hybrid Electric vehicle.

Solar Energy

Solar Energy is a form of fuel that can be used as an alternative fuel in plug-in electric cars. The vehicle will be powered by solar electricity obtained from the solar panels on the surface. Photovoltaic cells convert the sun's energy into directly into the electrical energy. Even though it doesn't make any change in the form of fuel that is being used, but the mileage of the direct plug-in electric vehicle can be significantly increased by using these PV cells. But, the only backdrop in adapting this technology into the plug-in electric vehicle is that, these PV cells can work only in the places with abundant solar energy and will not be used during the dark.

1. 5 Classification of Hybrid Electric Vehicles

Hybrid electric vehicles can be classified basing on some factors. Such as,

The path in which power is supplied to the power train.

Degree of hybridization.

Path of Power supplied to the Powertrain

The classification of HEVs can be done basing on the way of power supplied to the powertrain. According to this, the vehicles can be classified as,

Parallel hybrids

Series hybrids

Series-Parallel hybrids

Plug-in HEVs

Parallel Hybrids

In a Parallel HEV, the Internal Combustion engine and the electric motor are connected to the mechanical transmission and can simultaneously transmit the power to wheels through the conventional transmission. Usually, parallel hybrids use small and single electric motors and depend on a small battery pack because the motor does not have the capacity to be the only source of energy to run the vehicle. Parallel hybrids are also capable of, using Regenerative braking to some limited levels and IC engine will also act as a generator for supplementary recharging. Parallel hybrids are much efficient compared to non-hybrid vehicles, particularly in the urban driving conditions and sometimes during highway operations, when the electric motors contribution is permitted. Honda Insight, Civic, Accord, and Chevrolet Malibu are some of the examples for the parallel hybrids in production.

Series Hybrids

In a Series HEV, only electric motor drives the powertrain and Internal Combustion engine acts as a generator to charge the batteries which empower the electric motor. In series hybrid vehicles, battery pack will be charged from the regenerative braking or the Internal Combustion engine. Series hybrids generally have small internal combustion engine but large battery pack compared to the parallel hybrid vehicles. This is the factor which makes series hybrids more efficient when driving in city conditions and more expensive than parallel hybrid vehicles. Chevrolet Volt is an example for a series hybrid in production.

Series-Parallel Hybrids

These vehicles are flexible to operate in parallel or series mode. As a result, these vehicles will be more efficient, because these will be operated as a series hybrid in low speeds and parallel in high speeds. But, these vehicles are costlier compared with a pure parallel. Hybrid powertrains are currently being used by General Motors, Ford, Nissan, Lexus, and Toyota. Vehicles referring to " Series-Parallel" can operate in both the parallel and series mode at the same time. Toyota Highlander is an example for Series-Parallel hybrids.

Plug-in Hybrids

Plug-in hybrid is a type of hybrid vehicle which works rechargeable batteries, which could be stored to full charge by plugging into an external source of power. This type of vehicles shares the features of a conventional HEV, having an Internal Combustion engine and an Electric motor; and with all-

electric vehicle, provided with a plug that should be connected to the external source. These vehicles have well-built all-electric range compared to conventional gasoline electric hybrids, and combustion engine provides with backup needed when batteries are depleted. Chinese automobile manufacturer BYD Auto released F3DM hatchback into Chinese market in December 2008 and General Motors expects to launch Chevrolet Volt series plug-in by November 2010.

Classification by Degree of Hybridization

The hybrid electric vehicles can be classified further basing on the factor, the extent to which the vehicle is hybridized. According to this, the HEVs can be classified into,

Full Hybrid

Mild Hybrid

Power assist Hybrids

Full Hybrids

This is a type of Hybrid vehicle which can run just only on the batteries, or just on the engine alone, or the combination of both. Ford's Hybrid System, Toyota's Hybrid Synergy Drive, General Motors's Two-Mode Hybrid technology are some of full hybrid systems. A high-capacity battery pack will be needed for the battery only operation. These vehicles will have split path for power, which allows with more flexibility in the drivetrain by inter-converting mechanical and electrical power, although it is complex. Ford

Escape Hybrid, Toyota Prius, and Ford Fusion Hybrid are some examples for full hybrid vehicles.

Mild Hybrids

This is a vehicle, which cannot be driven by depending only on the power produced by the electric motor itself. Since, the electric motor does not have enough power to propel the vehicle on its own. These vehicles are only included with some features of hybrid technology, and achieve limited savings on fuel consumption.

A Mild hybrid is a vehicle more of a conventional type with oversized starter motor which allows the engine to turn off whenever the vehicle is decelerating or stopped. Yet, restart cleanly and quickly. Even when the gasoline engine was turned off, accessories will continue to run on the electric power, and like the other hybrid designs, motor will be used for regenerative braking to bring back all the energy. Mild hybrids have comparatively small batteries and a weak, small generator/ motor than those of a fully hybrid vehicle which helps in reducing weight and cost of production. The BMW Concept 7 Series Active Hybrid is an example of a Mild Hybrid with an electric motor designed to increase performance and power.

Power Assist Hybrids

These vehicles use the IC engine for primary power source, and torque-boosting electric motor is also connected to a large conventional power train. The electric motor is mounted between the transmission system and engine should be a very large starter motor essentially. This motor not only operates when the engine needs to be turned on, but also when extra power is

needed. The electric motor may also be used to restart the IC engine, Deriving benefits from shutting down the main engine at idle, while the battery system will be used to run the other power accessories.

Advantages and Disadvantages of HEVs over Conventional Petrol or Diesel Vehicles

Fuel Consumption

The consumption of petroleum is comparatively less and efficiency is much better in HEVs than the conventional petrol or diesel engines. Since, using three mechanisms:

Reducing the wastage of energy during low/idle output, usually by turning off the IC engine.

Utilizing the waste energy (i. e. by regenerative braking)

Reduction in power and size of the IC engine, and hence inefficiencies from under-utilization, the extra power output from the electric motor compensate the loss in peak power output from the IC engine.

Any combinations of these three primary advantages of a hybrid technology may be used for different fuel usage, emissions, power. The power curve of an electric motor is suits to more variable speed levels, and will provide significantly high torque at low speeds compared to IC engines. Thus, greater fuel efficiency of HEVs has inference for reduction in fuel consumption and emission of air pollutants.

Noise

The noise emitted from HEVs is comparatively very low than that of a conservative gasoline or diesel engine vehicle, results in positive noise health effects. Though, the sounds from the tires (road noise), the loudest noise at highway speeds from the vehicle interiors cannot be prevented by the hybrid design alone.

Pollution

The fuel used in HEVs is less of petroleum products which will emit carbon oxides into the atmosphere and hence pollution created will be less comparatively to the conventional gasoline or diesel engines. These vehicles will have a very positive impact onto the environment. But, the problem is with decomposing the dead batteries which are made of metals like Ni those can oxidise and produce metal oxides which can cause pollution in the environment.

Weight of the vehicle

The mass of a HEV is comparatively lesser than that of a conventional gasoline or diesel engine vehicles as the components used in the hybrid cars are less in weight than those of IC engine vehicles. This factor helps in reducing the consumption of extra initial torque required to move the vehicle from rest.

Disadvantages of HEVs over Conventional Petrol or Diesel Vehicles

As with all new technology, hybrids are relatively expensive.

Shortage in awareness of knowledge about hybrids with the technicians to deal effectively with these vehicles.

High maintenance

Low towing capacity

Batteries are expensive, heavy and have a short life span and are an environmental hazard.

Decomposition of batteries is a big challenge for the manufacturers, as the batteries are useless after they were dead and can be hazardous to the environment.