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DESIGN AND ANALYSIS OF HYBRID ELECTRIC VEHICLE [HEV]

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Abstract

Hybrid Vehicle fuel economy and drivability performance are very sensitive to the "Energy Management" controller that regulates power flow among the various energy sources and sinks. Many methods have been proposed for designing such controllers. Most analytical studies evaluate closed-loop performance on government test cycles. A hybrid vehicle structure comprising fuel cell/battery and a DC electrical machine has been proposed, in which an intelligent controller is to perform power management and regenerative braking tasks. Instead of a gasoline engine, an electric machine fulfills the power demand from the vehicle during driving and braking modes. In addition, regenerative braking is possible in the proposed structure. The fuel cell is connected to a battery (DC bus) via a DC/DC converter which can control the fuel cell power/current with a switching strategy. Duty cycle of the DC/DC converter is computed by the driving controller and applied with a certain switching frequency. Along with the power demand, braking pedal displacement, and the battery state of charge act as controlling signals, which allow the power management controller to perform pertinent analysis for power sharing decision between both the power sources. A threshold zone has been considered for braking pedal, according to which a regenerative torque is produced by the electrical machine. Finally, the simulation results have been considered from different point of views and evaluated, which shows a tenable achievement. Particularly, a series of driving manoeuvres were applied to the vehicle, and the results show that the proposed structure has a promising performance as a civic automobile with zero emissions.

Keyword: *ICEV- Internal combustion engine vehicles, HEV- Hybrid Electric Vehicles, ECU- Electronic controlling unit, PHEV-plug-in hybrid electric vehicles*

I INTRODUCTION

Internal combustion engine vehicles (ICEVs) have experienced continuous development in manufacturing technology, materials science, motor performance, vehicle control, driver comfort and security for more than a century. ICE efficiency is incredibly low. Solely 30% of the energy produced in the ICE combustion reaction is converted into mechanical power, approximately 70% of the energy liberated by combustion is lost. In fact and worse than that, the wasted energy of thermal motors is transformed into motor and exhaust gases heat. The exhaust gases are a blend formed mostly of carbon dioxide (CO2) and, to a lower extent, nitrogen oxides (NOx), hydrocarbons (CxHy), carbon monoxide (CO). Air pollution in big cities is another serious problem caused by exhaust gases, which leads to respiratory system diseases, including lung cancer. Disturbing noise level is another issue related to big fleet of ICEVs in big cities. Hybrid Electric Vehicles (HEVs), i.e., those that combine ICE with electrical machines fed by batteries or fuel cells (hydrogen derived electricity), Their energy consumption ranges from 10% to 70% lower than that of an equivalent ICE car, depending on their power, battery size, control strategy, etc. Hybrid electric vehicles (HEVs) are powered by a combination of electricity and either petrol or diesel. The electricity is used only as an intermediate energy storage medium to improve the overall efficiency of the vehicle. They therefore DO NOT need to be plugged in to recharge the battery. This cuts down on the amount of fuel needed, producing fewer emissions and lowering overall fuel costs. Most hybrids also use 'regenerative braking', which captures energy from braking to be put back into the battery - this improves energy efficiency and reduces brake wear.

II ARCHITECTURE

Hybrid technology operates to improve the overall efficiency of the use of petrol or diesel fuel. It does this by operating a smaller (more efficient) internal combustion engine within a narrower, more efficient operational speed/power band and using an electric engine and electrical storage to balance the vehicle's energy requirements. While BEVs are propelled by electric motors only, HEVs employ both ICE and electric motor in their power trains. The way these two energy converters are combined to propel the vehicle determines to the three basic power train architectures: series hybrid, parallel hybrid, and series-parallel hybrid.

In series HEVs the wheels are only driven by the electric motor that also operates as generator during break and coasting, augmenting thus the overall energy efficiency. This topology simplifies the powertrain design, since clutch and reduction gear are not necessary. Speed and torque control is carried out by controlling the electric motor only, which is a very efficient power converter. The ICE's role is charging (or recharging) the battery and supplying energy to the electric motor, always being operated at maximum efficiency. This is another strategy that helps increasing the overall energy efficiency. Series HEVs are said to be ICE-assisted electric vehicles, for obvious reasons. An ICE, one generator and one motor are one of the main disadvantages of series HEV. Moreover, as the vehicles must be capable of cruising with maximum load against a graded road, all the machines, i.e., the ICE, the generator and, of course, the electric motor, must be powerful enough, which will result in relatively over-dimensioned machines which leads to cost increase.

III. RELATED THEORY

A. Hybrid solar car Components -Electric vehicle was first designing and developing by the Baker Motor Company since 1990s. A main advantage of EV over the internal combustion engine can thus be exploited in terms of no carbon emissions occurred due to only use the electric motor to drive the engine. Generally, the electric car and hybrid car is consisted of six main parts: electric motor, electric Generator, battery bank, IC engine and electronic controlling unit (ECU) respectively.

Main components of hybrid solar car:

(1) PV panel convert sunlight into electricity, which is stored in batteries. Then its energy will be utilized for hybrid car propulsion.

(2) Electric motor has, generally, been employed for driving the hybrid solar car (HSC). However, we can observe that the brushless DC motor (BLDC) is often operated in the (HSC)over the classical DC motor due to long lifetime operation, high speed and also high torque.

(3) Electric Generator is self energy generated in a car during a regeneration brake or slop on a road.

(4) Battery bank is an important component for the HSC. It has been generated 24 V DC for supplying to the electric motor and also electronic devices in the HSC.

(5) IC engine has been employed for driving of hybrid solar car which can be used during a night or minimum electric energy of HSC.

(6)Electronic controlling unit (ECU) is an electronics circuit that is used for controlling the energy in the electric motor which can be provides a speed variation.

B. Transmission system – In this hybrid solar car, we are using two types of transmission system as below with a diagram of the transmission system of hybrid car can thus be illustrated in Fig. 1

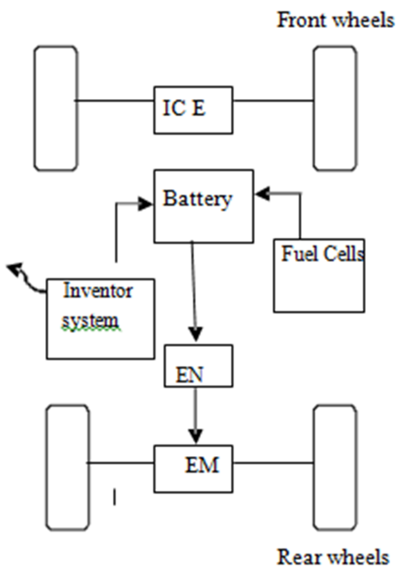
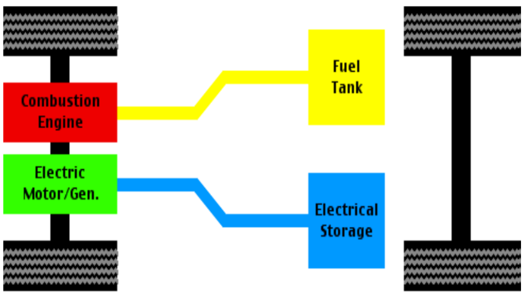


Figure 1. A general Transmission system of Hybrid Electricr car

Application of break and regenerative breaking :

In the traditional braking system, brake pads produce friction with the brake rotors to slow Down or stop the vehicle. Additional friction is produced between the slowed wheels and the surface of the road. This friction turns the kinetic energy of the car to heat. With regenerative brakes, on the other hand, the system that drives the vehicle does the majority of the braking. When the driver steps on the brake pedal of an electric or hybrid vehicle, these types of brakes put the vehicle's electric motor into reverse mode or reverses the terminal of the electric motor causing it to run backwards, thus slows the car's wheels. While running backwards, the motor also acts as an electric generator that delivers the current from the load to the source producing electricity that's then fed into the vehicle's batteries. These types of brakes work better at certain speeds than at others. So it has an advantages when the break is applied the heat energy developed by the regenerative breaking process, soon converts to the electrical energy. When the regenerative breaking doesn't supply enough electric power, then vehicle must have a backup system.

Parallel Hybrid



Series Hybrid

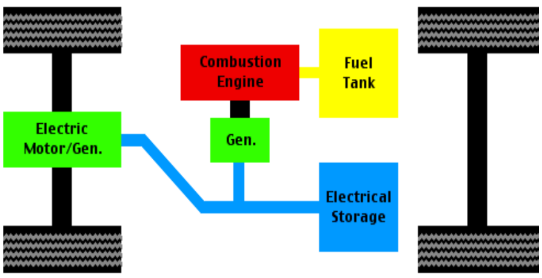
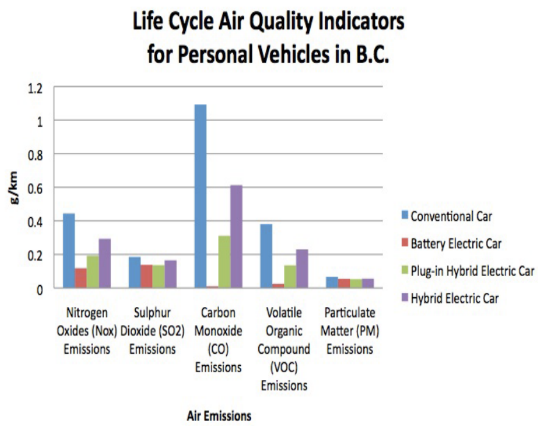


Figure 2.3: Parallel and series hybrid configurations

GAS EMISSION CONTROL:

An average gasoline vehicle produces 325 grams of carbon dioxide equivalent for every kilometre it is driven. The majority of these emissions are from the tailpipe of the vehicle (the blue section) and the rest from producing the fuel (red section) and producing the vehicle (green section). Battery electric, plug-in hybrid electric and gasoline hybrids reduce emissions by 80%, 55% and 30% respectively relative to an average gasoline vehicle. The main reason for this better performance is that B.C.'s electricity grid is primarily hydroelectric. EVs are able to use low carbon electricity in place of gasoline. Hybrid gasoline vehicles do not use the grid and achieve reductions because of increased fuel efficiency relative to gasoline vehicles. It is worth noting that EV vehicle and battery production (green section) is more energy intensive than a gasoline vehicle; however, reduced GHG emissions during its operation far outweigh the additional energy required to produce the vehicles. The amount of tailpipe air pollutants, such as carbon monoxide, volatile organic compounds and particulate matter, emitted from each type of vehicle and found EVs emitted less of five key dangerous air pollutants than conventional cars. These results are not divided into vehicle manufacture, fuel production and tailpipe emissions.

For all air emissions, battery electric, plug-in hybrid electric and hybrid electric vehicles outperform combustion vehicles. These reductions are significant and can range from 10% reductions in SO2 emissions for plug-in hybrid EVs to 99% reductions in CO emissions for battery EVs. Equally important is the location of the air emission reductions. In most cases all three of the alternative vehicle technologies lead to reduced tailpipe, or local air pollutants that generate smog, acid rain and respiratory ailments. They also do not lead to significant increases in air emissions elsewhere in the life-cycle of the vehicle. The main reason for the result in electricity is primarily generated from hydro-electric facilities. Hybrid electrics lead to reduced emissions because they are more fuel efficient than conventional vehicles.



BATTERY – FUEL CELLS

The SimaPro tool only contained data on the production of small consumer size batteries. Data on recycling for Nickel-Metal Hydride (Ni-MH) batteries, was therefore based on a life cycle assessment report on batteries for electric vehicles. The work focused on one specific battery from each of the systems and the results were representative of these particular batteries and not of the battery systems to which they belong. For Ni-MH batteries, the report provided data on the energy requirements for manufacturing the battery (in MJ/kg battery), the energy required for recycling the battery (MJ/kg battery), the emissions from manufacturing the battery (kg/kg battery), and the emissions from recycling the battery (kg/kg battery). The data was entered into SimaPro to obtain total emissions from manufacturing and recycling the batteries. Data for lithium ion batteries in SimaPro is for a small 'AA' size battery and only for production emissions, but this was the best data which could be found. The emissions from production and recycling/disposal of Li-ion batteries were therefore also estimated from their component materials according to Table and used to generate emission factors for recycling/disposal consistent with the production data already in SimaPro. Hopefully research on batteries will end up by boosting their energy and power densities as well as significantly decreasing their production cost. In a nutshell, these are the main barriers for mass diffusion of BEVs, PHEVs and conventional HEVs. Though today's technology is appropriate to EVs, from the driving range and vehicle performance, cost is still quite high for consumers.

Table: Material content of different types of rechargeable battery

Material	**Pb-acid**	**NiMH**	**Li-ion**
Lead	61.0%		
Nickel		26.5%	
Lithium			1.0%
Copper			13.0%
Cobalt or Manganese			15.0%
Aluminium			28.0%
Steel		43.5%	8.5%
Plastic	8.5%	5.0%	8.5%
Water, acid/alkali	27.0%	9.0%	
Other	3.5%	16.0%	26.0%
Total	**100%**	**100%**	**100%**

Establish programs for battery recycling and proper disposal. Recycling programs should be in place before PHEVs proliferate to keep batteries out of landfills.

Encourage off-peak battery charging. Power companies have excess capacity at night and should price electricity to encourage battery charging during low-demand periods. However, because significant amounts of off-peak power could come from existing coal plants, this increases the importance of cleaning up these sources, both for conventional pollutants and for global warming pollution.

CAPITAL AND OPERATING COSTS:

The cost of ownership of a HEV primarily depends on the cost of the battery. Battery costs make up a significant proportion of the overall capital cost of HEVs. The type and capacity of the battery will determine the maximum speed, travel range, battery lifetime and re-charging time. Prices have fallen in recent years and are expected to continue to fall with increasing demand. Due to the potentially high costs involved, some manufacturers offer the opportunity of leasing or renting the battery from them rather than having to buy it. The high purchase costs for HEVs are partially offset through reduced energy costs; fuel-running costs are low due to the competitive price of electricity and due to the high efficiency of the vehicle. It can cost as little as 1.5 cents to run a car on electricity for a mile compared to approximately 15 cents per mile with petrol[7]. Non-energy running costs (tax and maintenance) are however higher than for conventional petrol and diesel equivalents. This leads to the overall ownership costs (covering purchase, energy, and operational costs) for BEVs being higher than for petrol and diesel equivalents. indicative cost information for owning a battery electric car, van, mini-bus and midi-bus under the "average" scenario. The financial information shown relates to costs incurred over the ownership period. Note that this information does not include the treatment of business vehicles for tax purposes.

DISCUSSION

The results show that the majority of participants had misconceptions regarding HEVs. What most of the participants knew was where HEVs are available and that they cost more compared to CVs. They also indicated correctly that HEVs have better fuel efficiency and less environmental impacts. Apart from that, most of the participants had misconceptions about the maintenance and performance of HEVs. These are very important misconceptions because they are major factors that consumers consider when purchasing a vehicle. The majority of the participants indicated that they would be willing to pay $1000 - $5000 more for an HEV version of a car that could meet all their requirements. This shows that people are interested in the environmental impacts of driving. The limited variability in models of HEVs is an obstacle for their market success; however, most of the participants indicated that they are interested in purchasing sedans, which is currently the only style of vehicle using hybrid electric technology. Also, for consumers who are discouraged by the HEV's unique or awkward appearance, the new hybrids will look no different from the styles of CVs they are accustomed to – for example, the new hybrid Honda Civic is simply a hybrid version of a popular vehicle. A very common misconception was that HEVs need to be plugged in overnight for recharging. The majority of the participants also indicated that they don't think HEVs perform as well as CVs, and performance was chosen as the highest ranking factor influencing their car buying decision. Overcoming these misconceptions regarding the maintenance and performance of HEVs could lead to an increase in sales. Accurate information aimed at the public about the benefits and conveniences of HEVs is vital for their market success (Barber, 1993). The survey for this study unfortunately did not contain very structured questions. The questions dealt only with basic interests and did not span a very wide range of misconceptions. Questions aimed at how the price and accessories of a vehicle influence people with varying incomes is just an example of how the survey could have been modified to produce more specific data which could then have shown some associations between income and the publics' perceptions or interests. The public has many different perceptions of HEVs, and although the survey didn't show many associations between age and misperceptions, shortening the age gap in each of the age groups (i.e. grouping participants into ages 20-25, 25-30, etc. instead of 20-35, 35-50) could reveal more associations. The sample size for this study was small. A larger sample size could reveal more trends. The results of this study showed that the public probably still has some misconceptions about HEVs.

CONCLUSION

HEVs give a clear solution to climate change and air quality concerns. This is largely due to the fact that electricity is generated from largely (93%) renewable resources. Electricity generation from renewable sources does have other environmental impacts. Energy conservation can reduce the amount of electricity needed and good planning can minimize the impacts of any new projects. Manufacturers are currently developing plug-in hybrid electric vehicles (PHEVs), with much bigger batteries, representing a bridge between HEV and BEV technology

The primary conclusions of this analysis are summarized below:

- Battery electric, plug-in hybrid electric and hybrid electric vehicles reduce life-cycle greenhouse gas emissions by 80%, 55% and 30% respectively in comparison with gasoline vehicles.
- Battery electric, plug-in hybrid electric and hybrid electric vehicles reduce life-cycle air emissions of NOx, SO2, VOCs, PM and CO. The reductions range from 10% to 99% depending on the pollutant and the vehicle.
- Battery electric, plug-in hybrid electric and hybrid electric vehicles could be effective tools to reduce smog and respiratory ailments in urban centres because they primarily reduce local air emissions relative to gasoline vehicles.
- Manufacturing battery electric, plug-in hybrid electric and hybrid electric vehicles produces more GHG emissions and air emissions than a gasoline vehicle; however, this increase in emissions is outweighed by the reductions achieved during the operation of the vehicle.
- B.C.'s electricity grid, which is primarily hydroelectric, is the main reason the battery electric, and plug-in hybrid EVs outperform gasoline vehicles. In a more fossil fuel intensive grid, such as Alberta's, the benefits of battery electric and plug-in hybrid EVs is undermined by a reliance on coal for electricity production. For example, driving a battery electric in Alberta results in just about 4 g/km CO2e savings46 or 1.1%, while driving a classic hybrid electric in Alberta achieves 104 g/km CO2e savings, or 30% over a conventional vehicle.
- Hybrid electric vehicles outperform conventional vehicles because of their increased fuel efficiency.

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