HYBRID VEHICLES: INSANE STUDY

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Abstract

With the advancement in 21st Century, there has been increase in usage of Oil and Gas leading to problems like Global Warming, climate change, shortage of crude oil, etc. In an effort to promote public awareness, this paper reviews hybrid vehicle technology as a logical step towards sustainable, efficient future and environment friendly transportation. The paper starts from brief history about Hybrid Technology and also some brief introduction on it. Paper will also discuss the technologies used in the making of Hybrid Cars and their types. Paper concludes on the advantages and dis-advantages of Hybrid Cars and how this technology will take over the world in future and would become the alternative for Petrol and Diesel Cars.

Keywords - hybrid electric vehicle; hybrid solar vehicle; environment; Astrolab; SLS Electra

I. Introduction

With the invention of Internal Combustion Engine by Nicolas Otto, there was revolution in Automobile field. Later on, Petrol and Diesel became the main source of fuel for these vehicles. This technology made Human Efforts very easy through commercializing in the market. Due, to which it became the commercial success and its use in the day to day period increased. As we know everything has its own positive and negative side. The rate of Carbon Monoxide (CO) and Carbon Dioxide (CO2) suddenly increased at the dangerous level in the beginning of 21st Century which made a negative impact on Ecosystem, reason for Global Warming, Health related issues, etc. This forced Scientist, Researchers and Policymakers to focus or made them start thinking for Green Technology or the technology which can stop the adverse effect happening on Nature. Hence, the 21st Century will become the Century for Evolution in various technologies with the main focus in Automobile Sector. The technologies which will change the face of Automobile Sector would be “Hybrid Electric Vehicle”, “Hybrid Solar Vehicle”, “Hydrogen Fuel Cell”, etc. while Hybrid Solar Vehicle has lower efficiency than vehicle running on Petrol/Diesel/CNG. So, this technology is for drivers who want to cover less distance. To overcome this constraint, “Plug-In Hybrid Electric Vehicle” came into existence.

II. Working Principle of Hybrid Vehicle

Regenerative braking is an energy recovery mechanism which slows down a vehicle by converting its kinetic energy into another form, normally into electrical energy, which can be used immediately or stored until needed in high voltage batteries. The electric motor is operated in reverse during braking or coasting, acting as generator. The rotors of electric traction motor are coupled with wheels; they experience opposing torque as current is induced in the motor coils. The wheels transfer kinetic energy via drivetrain to generator. At the same time, generator resistance produced from the electricity created, slows the vehicle. When more braking torque is required than the generator alone can provide, additional braking is accomplished by friction brakes. Depending on the drive train structure (how motor and engine are connected), we can distinguish between parallel, series or combined HEVs. Depending on the share of the electromotor to the traction power, we can distinguish between mild or micro hybrid (start-stop systems), power assist hybrid, full hybrid and plug-in hybrid. Depending on the nature of the non-electric energy source, we can distinguish between combustion (ICE), fuel cell, hydraulic or pneumatic power, and human power. In the first case, the ICE is a spark ignition engines (gasoline) or compression ignition
direct injection (diesel) engine. In the first two cases, the energy conversion unit may be powered by gasoline, methanol, compressed natural gas, hydrogen, or other alternative fuels.

III. Types by drive train structure

A. Series hybrid

In a series hybrid system, the combustion engine drives an electric generator instead of directly driving the wheels. The electric motor is the only means of providing power to the wheels. The generator both charges a battery and powers an electric motor that moves the vehicle. When large amounts of power are required, the motor draws electricity from both the batteries and the generator. Series hybrid configurations already exist a long time: diesel-electric locomotives, hydraulic earth moving machines, diesel-electric power groups, and loaders. Series hybrids can be assisted by ultracaps, which can improve the efficiency by minimizing the losses in the battery. They deliver peak energy during acceleration and take regenerative energy during braking. Therefore, the ultra-caps are kept charged at low speed and almost empty at top speed. Deep cycling of the battery is reduced; the stress factor of the battery is lowered. Some vehicle designs have separate electric motors for each wheel. Motor integration into the wheels has the disadvantage that the unsprung mass increases, decreasing ride performance. Advantages of individual wheel motors include simplified traction control (no conventional mechanical transmission elements such as gearbox, transmission shafts, differential), all-wheel drive, and allowing lower floors, which is useful for buses. Some 8x8 all-wheel drive military vehicles use individual wheel motors. A fuel cell hybrid electric always has a series configuration: the engine-generator combination is replaced by a fuel cell.

![Series Hybrid Diagram](image)

B. Parallel hybrid

Parallel hybrid systems have both an internal combustion engine (ICE) and an electric motor in parallel connected to a mechanical transmission. Most designs combine a large electrical generator and a motor into one unit, often located between the combustion engine and the transmission, replacing both the conventional starter motor and the alternator. The battery can be recharged during regenerative breaking, and during cruising. As there is a fixed mechanical link between the wheels and the motor (no clutch), the battery cannot be charged when the car isn’t moving. When the vehicle is using electrical traction power only, or during brake while regenerating energy, the ICE is not running (it is disconnected by a clutch) or is not powered (it rotates in an idling manner).

C. Operation modes

The parallel configuration supports diverse operating modes:

- Electric power only: Up to speeds of usually 40 km/h, the electric motor works with only the energy of the batteries, which are not recharged by the ICE. This is the usual way of operating around the city, as well as in reverse gear, since during reverse gear the speed is limited.
- ICE power only: At speeds superior to 40 km/h, only the heat engine operates. This is the normal operating way at the road.
- ICE + electric power: if more energy is needed (during acceleration or at high speed), the electric motor starts working in parallel to the heat engine, achieving greater power.
- ICE + battery charging: if less power is required, excess of energy is used to charge the batteries. Operating the engine at higher torque than necessary, it runs at a higher efficiency.
- Regenerative breaking: While braking or decelerating, the electric motor takes profit of the kinetic energy of the moving vehicle to act as a generator.
- Sometimes, an extra generator is used: then the batteries can be recharged when the vehicle is not driving, the ICE operates disconnected from the transmission. But this system gives an increased weight and price to the HEV.

Example of PHEV

Honda Civic. Honda’s IMA (Integrated Motor Assist) uses a rather traditional ICE with continuously variable
transmission, where the flywheel is replaced with an electric motor.

Influence of scale: A Volvo 26-ton truck (12-ton own weight, 14-ton max load) equipped with 200 kg of batteries can drive on pure electric power for 2 minutes only! Because of space constraints, it is not possible to build in more batteries. BMW 7Series Active Hybrid

D. Combined hybrid

Combined hybrid systems have features of both series and parallel hybrids. There is a double connection between the engine and the drive axle: mechanical and electrical. This split power path allows interconnecting mechanical and electrical power, at some cost in complexity. Power-split devices are incorporated in the powertrain. The power to the wheels can be either mechanical or electrical or both. This is also the case in parallel hybrids. But the main principle behind the combined system is the decoupling of the power supplied by the engine from the power demanded by the driver. In a combined hybrid, a smaller, less flexible, and highly efficient engine can be used. It is often a variation of the conventional Otto cycle, such as the Miller or Atkinson cycle. This contributes significantly to the higher overall efficiency of the vehicle, with regenerative braking playing a much smaller role. At lower speeds, this system operates as a series HEV, while at high speeds, where the series powertrain is less efficient, the engine takes over. This system is more expensive than a pure parallel system as it needs an extra generator, a mechanical split power system and more computing power to control the dual system.

Example of CHEV: Toyota Prius, Auris, Lexus CT200h, Lexus RX400h.

Parallel and combined hybrids can be categorized depending upon how balanced the different portions are at providing motive power. In some cases, the combustion engine is the dominant portion; the electric motor turns on only when a boost is needed. Others can run with just the electric system operating.

E. Strong hybrid (full hybrid)

The Toyota Prius, Auris and Lexus are full hybrids, as these cars can be moved forward on battery power alone. The Toyota brand name for this technology is Hybrid Synergy Drive. A computer oversees operation of the entire system, determining if engine or motor, or both should be running. The ICE will be shut off when the electric motor is sufficient to provide the power.

F. Medium hybrid (motor assist hybrid)

Honda's hybrids including the Civic and the Insight use this design, leveraging their reputation for design of small, efficient gasoline engines; their system is dubbed Integrated Motor Assist (IMA). Starting with the 2006 Civic Hybrid, the IMA system now can propel the vehicle solely on electric power during medium speed cruising. A variation on this type of hybrid is the Saturn VUE Green Line hybrid system that uses a smaller electric motor (mounted to the side of the engine), and battery pack than the Honda IMA, but functions similarly.

G. Mild hybrid / micro hybrid (start/stop systems with energy recuperation)

Mild hybrids are essentially conventional vehicles with oversized starter motors, allowing the engine to be turned off whenever the car is coasting, braking, or stopped, yet restart quickly and cleanly. During restart, the larger motor is used to spin up the engine to operating rpm speeds before injecting any fuel. That concept is not unique to hybrids; Subaru pioneered this feature in the early 1980s, and the Volkswagen Lupo 3L is one example of a conventional vehicle that shuts off its engine when at a stop. As in other hybrid designs, the motor is used for regenerative braking to recapture energy.
But there is no motor-assist, and no EV mode at all. Therefore, many people do not consider these to be hybrids, since there is no electric motor to drive the vehicle, and these vehicles do not achieve the fuel economy of real hybrid models. BMW succeeded in combining regenerative braking with the mild hybrid "start-stop" system in their current 1-series model.

### H. Plug-in hybrid (grid connected hybrid)

A plug-in hybrid electric vehicle (PHEV) is a full hybrid, able to run in electric-only mode, with larger batteries and the ability to recharge from the electric power grid. Their main benefit is that they can be gasoline-independent for daily commuting, but also have the extended range of a hybrid for long trips. Mercedes Blue ZERO E-CELL PLUS (concept car): series HEV. The Plug-in-Hybrid Volvo C30 (concept car) is a series HEV. It has a 1.6-liter gasoline/bio-ethanol ICE. A synchronous generator charges the Li-polymer battery (ca. 100 km autonomy) when the battery SoC is lower than 30%. There are four electric wheel-motors.

### IV. Types by nature of the power source

#### A. Electric-internal combustion engine hybrid

There are many ways to create an electric-internal combustion hybrid. The variety of electric-ICE designs can be differentiated by how the electric and combustion portions of the powertrain connect (series, parallel or combined), at what times each portion is in operation, and what percent of the power is provided by each hybrid component. Many designs shut off the internal combustion engine when it is not needed in order to save energy.

#### B. Fuel cell hybrid

Fuel cell vehicles have a series hybrid configuration. They are often fitted with a battery or super capacitor to deliver peak acceleration power and to reduce the size and power constraints on the fuel cell (and thus its cost).

#### C. Human power and environmental power hybrids

Many land and water vehicles use human power combined with a further power source. Common are parallel hybrids, e.g. a boat being rowed and also having a sail set, or motorized bicycles. Also some series hybrids exist. Such vehicles can be trepid vehicles, combining at the same time three power sources e.g. from on-board solar cells, from grid-charged batteries, and from pedals.

The following examples don’t use electrical power, but can be considered as hybrids as well:

#### A. Pneumatic hybrid

Compressed air can also power a hybrid car with a gasoline compressor to provide the power. Moteur Development International in France produces such air cars. A team led by Tsu-Chin Tsao, a UCLA mechanical and aerospace engineering professor, is collaborating with engineers from Ford to get Pneumatic hybrid technology up and running. The system is similar to that of a hybrid-electric vehicle in that braking energy is harnessed and stored to assist the engine as needed during acceleration.

#### B. Hydraulic hybrid

A hydraulic hybrid vehicle uses hydraulic and mechanical components instead of electrical ones. A variable displacement pump replaces the motor/generator, and a hydraulic accumulator (which stores energy as highly compressed nitrogen gas) replaces the batteries. The hydraulic accumulator, which is essentially a pressure tank, is potentially cheaper and more durable than batteries. Hydraulic hybrid technology was originally developed by Volvo Flygmotor and was used experimentally in buses from the early 1980s and is still an active area. Initial concept involved a giant flywheel (Gyrobus) for storage connected to a hydrostatic transmission, but it was later changed to a simpler system using a hydraulic accumulator connected to a hydraulic pump/motor. It is also being actively developed by Eaton and several other companies, primarily in heavy vehicles like buses, trucks and military vehicles. An example is the Ford F-350 Mighty Tonka concept truck shown in 2002. It features an Eaton system that can accelerate the truck up to highway speeds.

### V. Advantages and Disadvantages

#### A. Advantages

1. **Environmentally Friendly**: A hybrid vehicle runs on twin powered engine (gasoline engine and electric motor) that cuts fuel consumption and conserves energy.
2. **Financial Benefits**: Hybrid cars are supported by many credits and incentives that help to make them affordable. Lower annual tax bills and exemption
from congestion charges comes, in the form of less amount of money spent on the fuel.

3. **Less Dependence on Fossil Fuels:** A Hybrid car is much cleaner and requires less fuel to run which means less emissions and less dependence on fossil fuels. This in turn also helps to reduce the price of gasoline in domestic market.

4. **Regenerative Braking System:** Each time you apply brake while driving a hybrid vehicle helps you to recharge your battery a little. An internal mechanism kicks in that captures the energy released and uses it to charge the battery which in turn eliminates the amount of time and need for stopping to recharge the battery periodically.

5. **Built from Light Materials:** Hybrid vehicles are made up of lighter materials which means less energy is required to run. The engine is also smaller and lighter which also saves much energy.

6. **Higher Resale Value:** With continuous increase in price of gasoline, more and more people are turning towards hybrid cars. The result is that these green vehicles have started commanding higher than average resale values.

**B. Disadvantages**

1. **Less Power:** Hybrid cars are twin powered engine. The gasoline engine which is primary source of power is much smaller as compared to what you get in single engine powered car and electric motor is low power. The combined power of both is often less than that of gas powered engine. It is therefore suited for city driving and not for speed and acceleration.

2. **Can be Expensive:** The biggest drawback of having a hybrid car is that it can burn a hole in your pocket. Hybrid cars are comparatively expensive than a regular petrol car and more than a standard version. However, that extra amount can be offset with lower running cost and tax exemptions.

3. **Poorer Handling:** A hybrid car houses a gasoline powered engine, a lighter electric engine and a pack of powerful batteries. This adds weight and eats up the extra space in the car. Extra weight results in fuel inefficiency and manufacturers cut down weight which has resulted in motor and battery downsizing and less support in the suspension and body.

4. **Higher Maintenance Costs:** The presence of dual engine, continuous improvement in technology, and higher maintenance cost can make it difficult for mechanics to repair the car. It is also difficult to find a mechanic with such an expertise.

5. **Presence of High Voltage in Batteries:** In case of an accident the high voltage present inside the batteries can prove lethal for you. There is a high chance of you getting electrocuted in such cases which can also make the task difficult for rescuers to get other passengers and driver out of the car. Making Your Decision Deciding whether or not a hybrid car is right for you involves more than just a desire to be environmentally friendly.
VI. Conclusion

We can reduce the cause of damage to our Mother Earth by using hybrid technology. Go green by spreading importance of saving nature, save it for our future generation. This paper gave us an insight into the methods of clean and efficient ways of transport and the necessary knowledge and the concepts required for imagining, designing and constructing this hybrid kart. And most importantly, it made us realize the importance and the need to keep our environment balanced and clean.

VII. Authors Biography

ARAVIND A K 2nd year B.E.Mechtronics Engineering student at Sri Krishna College of Engineering and Technology, Coimbatore. The focus of his research is to examine the key challenges in hybrid vehicle technology and identify potential short-comings in current policies for the promotion of hybrid vehicles in Society. He is part of IEEE society as chief Technical Head in IEE RAS Student chapter, SKCET.

ARAVIND SAI 3rd year B.E.Mechtronics Engineering student at Sri Krishna College of Engineering and Technology, Coimbatore. His research presently focuses on the analysis, design and control of hybrid electric vehicle and wind power applications, testing and performance analysis of design of hybrid energy management system.

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