International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Study and Development of Hybrid Vehicle

Prasad Satish Divekar[1], Dr. Thippeswamy Ekbote[2]

[1] Student, Machine Design M.Tech, Mechanical Engineering Department, B.I.E.T College, Davangere-577004 Karnataka, India

[2] Associate Professor and PG Co-Ordinator, Mechanical Engineering Department, B.I.E.T College, Davangere-577004 Karnataka, India

Abstract: ***Growing concerns over the limited supply of fossil-based fuels are motivating intense activity in the search for alternative road transportation propulsion systems. In addition, regulatory pressures to reduce urban pollution, CO2 emissions and city noise have made plug-in electric vehicles a very attractive choice as the alternative to the internal combustion engine. 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. As, the world went through 20th Century, there happened many advancements for making this technology efficient and cost-effective. Due, to which it became the commercial success and its use in the day to day period increased. People could reach thousands of kilometers / miles in hours with the help of this technology. In this paper, hybrid vehicle technology has been analyzed, with Power split configuration having internal combustion engine and battery as the power source. Initially the analysis of hybrid electric vehicle performance is done with battery of higher amp-hr capacity .In advanced state the converter circuit is implemented to reduce the battery rating. Different cases have been observed with different charging and discharging circuitry of battery. Hybrid electric vehicles are admired because of their ability to achieve related performance to a standard automobile while prominently improving fuel efficiency and tailpipe emissions.***

Keywords: Hybrid Vehicle, ICE, Electrical Motor Vehicle

1. Introduction

The technologies which will change the face of AutomobileSector would be "Hybrid Electric Vehicle", "Hybrid SolarVehicle", "Hydrogen Fuel Cell", etc. From all this HybridElectric Vehicle is considered as the most industriallymatured technology and has efficiency more than cars running on Petrol/Diesel/CNG while Hybrid Solar Vehicle has lowerefficiency 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 ElectricVehicle" came into existence. Regenerative braking is an energy recovery mechanism whichslows down a vehicle by converting its kinetic energy intoanother form, normally into electrical energy, which can beused immediately or stored until needed in high voltagebatteries. The electric motor is operated in reverse duringbraking or coasting, acting as generator. The rotors of electrictraction motor are coupled with wheels, they experienceopposing torque as current is induced in the motor coils.

A hybrid electric vehicle (HEV) has two types of energy storage units, electricity and fuel. Electricity means that a battery (sometimes assisted by ultracaps) is used to store the energy, and that an electromotor (from now on called motor) will be used as traction motor.

Fuel means that a tank is required, and that an Internal Combustion Engine (ICE, from now on called engine) is used to generate mechanical power, or that a fuel cell will be used to convert fuel to electrical energy. In the latter case, traction will be performed by the electromotor only. In the first case, the vehicle will have both an engine and a motor.

- 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.

Motors are the "work horses" of Hybrid Electric Vehicle drive systems. The electric traction motor drives the wheels of the vehicle. Unlike a traditional vehicle, where the engine must "ramp up" before full torque can be provided, an electric motor provides full torque at low speeds. The motor also has low noise and high efficiency. Other characteristics include excellent "off the line" acceleration, good drive control, good fault tolerance and flexibility in relation to voltage fluctuations.

The front-running motor technologies for HEV applications include PMSM (permanent magnet synchronous motor), BLDC (brushless DC motor), SRM (switched reluctance motor) and AC induction motor.

A main advantage of an electromotor is the possibility to function as generator. In all HEV systems, mechanical braking energy is regenerated.

The max.operational braking torque is less than the maximum traction torque; there is always a mechanical braking system integrated in a car.

The battery pack in a HEV has a much higher voltage than the SIL automotive 12 Volts battery, in order to reduce the currents and the I^2R losses.

Accessories such as power steering and air conditioning are powered by electric motors instead of being attached to the combustion engine. This allows efficiency gains as the accessories can run at a constant speed or can be switched off, regardless of how fast the combustion engine is running. Especially in long haul trucks, electrical power steering saves a lot of energy.

2. Types by Drivetrain Structure

2.1 Series hybrid

In a series hybrid system, the combustion engine drives an electric generator (usually a three-phase alternator plus rectifier) 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, loaders.

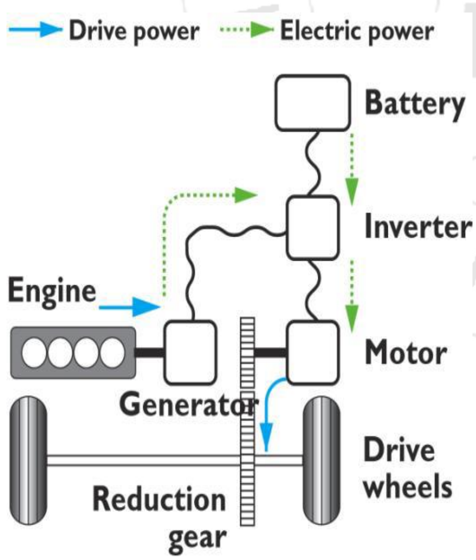


Figure 1: Structure of a series hybrid vehicle

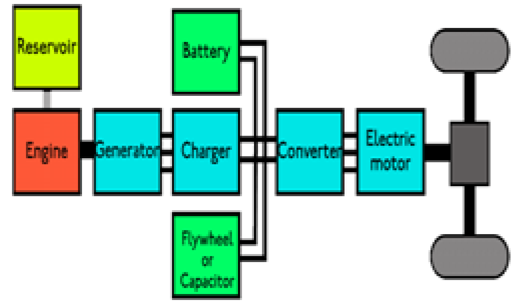


Figure 2: Flywheel or ultra-caps as peak power unit

A fuel cell hybrid electric always has a series configuration: the engine-generator combination is replaced by a fuel cell.

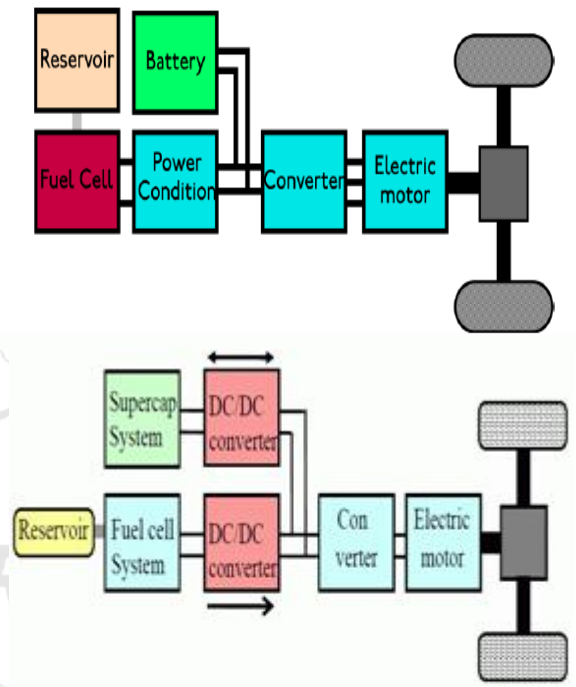


Figure 3: Structures of a fuel cell hybrid electric vehicle

2.2 Parallel hybrid

Parallel hybrid systems have both an internal combustion engine (ICE) and an electric motor in parallel connected to a mechanical transmission.

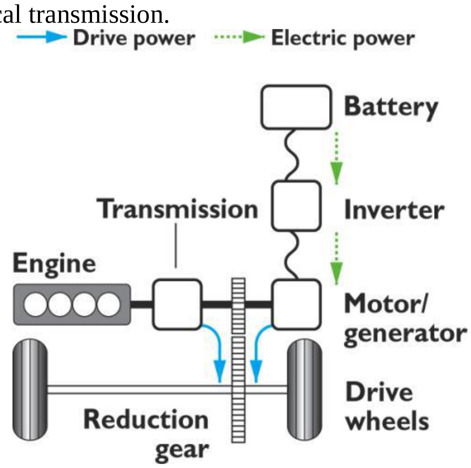


Figure 4: Structure of a parallel hybrid electric vehicle

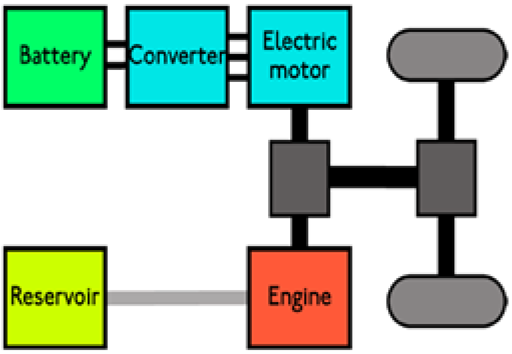
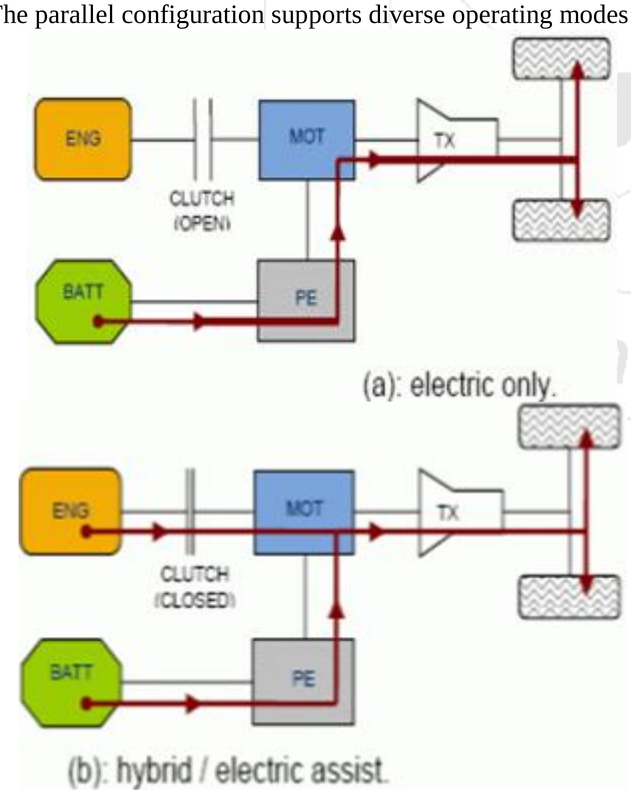


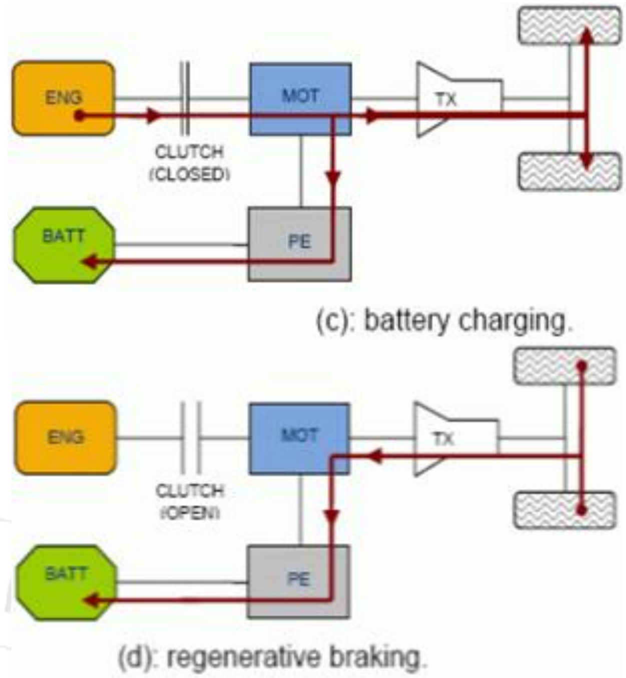
Figure 5: Block diagram of Parallel Hybrid vehicle

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 (see figures above). The battery can be recharged during regenerative breaking, and during cruising (when the ICE power is higher than the required power for propulsion). 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).

2.3 Operation modes

The parallel configuration supports diverse operating modes:





a) 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.
b) ICE power only: At speeds superior to 40 km/h, only the heat engine operates. This is the normal operating way at the road.
c) 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
d) 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.
e) regenerative breaking: While braking or decelerating, the electric motor takes profit of the kinetic energy of the he moving vehicle to act as a generator.

2.4 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.

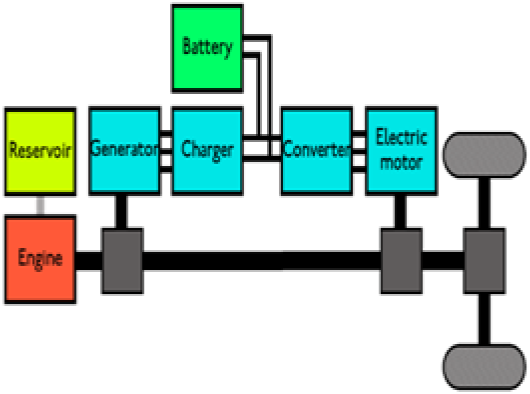


Figure 6: Simplified structure of a combined hybrid electric vehicle

In a conventional vehicle, a larger engine is used to provide acceleration from standstill than one needed for steady speed cruising. This is because a combustion engine's torque is minimal at lower RPMs, as the engine is its own air pump. On the other hand, an electric motor exhibits maximum torque at stall and is well suited to complement the engine's torque deficiency at low RPMs. 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.

1) Hybrid System Improvements in Development

Nissan, Hyundai/Kia, VW/Audi/Porsche, BMW, Subaru, and Mercedes have all recently introduced variants of a single-motor, twin-clutch hybrid system, commonly referred to as a P2 hybrid. Hyundai/Kia, with 8% of total 2014 hybrid sales, is by far the leading seller of P2 hybrids. P2 hybrid market share grew from 9% in 2013 to 12% in 2014. Hybrids, especially the P2 and lower-cost hybrid systems, remain at a relatively early stage of development. Seamlessly integrating engine, electric motor, battery, and regenerative braking functions is complex and difficult, requiring sophisticated simulations in the development process and powerful onboard computers to avoid drivability problems. One factor in the early success of the input power-split hybrid is that the planetary gear system helps to smooth out the transitions between the different power sources and reduces the development burden. Honda's early IMA system similarly reduced the development burden by bolting the motor directly to the engine. Unfortunately, as discussed earlier, the input power-split is a relatively expensive solution, and the IMA system is not competitive on benefits and costs with newer systems.

Less expensive hybrid systems will benefit greatly from the ongoing revolution in computer simulations, computer-aided design, and on-board computer controls. Indeed, the revolution in computers is essential to development of lower-cost systems with good drivability. This section outlines some of the more promising improvements that have recently emerged: batteries with higher power density, design improvements for P2 hybrids, and lower-cost 48v hybrid systems.

- VW-Audi is putting an e-booster system in production in 2015 on a V6 diesel.
- Schaeffler Group NA is demonstrating a concept 48v hybrid system on a 2013 Ford Fusion with about a 45% increase in mpg.
- BorgWarner stated that 48v systems are more affordable, as they use conventional components and have nice synergies with e-booster systems. A 48v eboost system alone can reduce CO2 emissions by 5–8g CO2, with higher peak power and slightly improved low end torque.
- Eaton's analyses found 48v hybrid systems can reduce CO2 by 10%–20% (depending on test cycle and the inclusion of e-boost superchargers), are 50%–75% cheaper than a full hybrid, and improve safety by staying below the 60v lethal threshold. They projected up to 3 million 48v units globally by 2020.
- Punch Powertrain found that mild hybrids could be moved to 48v at lower cost without much degradation in benefits.

In addition, there will be new developments that we arenot aware of yet, just as 48v hybrid systems are a veryrecent development. Hybrid component and systemdevelopment is accelerating, providing strong supportfor the continued improvements and cost reductions discussed above.

2) Impact of Weight Reduction on Cost

Reducing vehicle weight means that the powertrain can be downsized and still maintain constant performance. This applies directly to the electric motor propulsion system. A 10% reduction in weight will allow a 10% reduction in the electric propulsion motor and all supporting hybrid system components.

FEV 's baseline costs of $3,122 for the input power-split hybrid system in table 1 were for a European midsize car with a 78 kW motor. Thus, a 10% weight reduction would reduce the motor size 7.8 kW. Using the cost derived above for table 4 of 14.15 Euros per kW, the cost of the hybrid system would be reduced by $155, or about 5% of the total cost of the hybrid system.

3) P2 Hybrid Learning Opportunities

While the input power-split hybrid design used by Toyota and Ford is in its fourth generation of learning and development, P2 hybrids were only recently introduced. These first generation designs are at a much earlier point on the learning curve and have not been optimized. For example, all current P2 hybrids, including the P2 hybrids used by FEV in their tear-down cost assessments, install the motor between the engine and the transmission. This minimizes the amount of redesign required, which is important for first generation systems, but it requires a separate case, cooling system, oiling system, and clutch for the motor. It also compromises packaging of the powertrain, as extra space must be found to insert the motor. The impact of learning is illustrated by Hyundai's recent announcement about its second generation

P2 hybrid. This system will fully integrate the electric motor and almost all of the hybrid powertrain components within the transmission. The innovations include:

- A new traction motor
- Replacement of the mechanical oil pump with a new electric oil pump, which reduces hydraulic losses and automatically optimizes the system according to all driving conditions.
- The torque converter has been removed completely.
- A lighter torsion damper.
- A new engine clutch, which features fewer clutch discs, reducing drag and contributing to a more efficient transfer and use of power.
- With few components, the new transmission is lighter than the previous version yet still delivers 280 Nm (207 ft-lb) of torque.

These improvements minimize energy losses, increase fuel economy, and reduce costs. As P2 hybrid systems progress to third- and fourth-generation systems, there will be many additional opportunities for major cost reductions due to learning, such as:

- Use a less expensive conventional manual transmission instead of an automatic or dual-clutch transmission, enabled by using the electric motor to fill in the engine torque gaps.
- Eliminate the synchronizer rings and, instead, use the electric motor to match the revolutions of the engine and transmission gear on each shift.
- Create multiple power flow paths in a manual transmission to increase the number of effective gear ratios without increasing the number of gears (similar to current 6+ speed automatic transmission designs).
- Use less expensive techniques to coordinate friction brakes and regenerative braking.
- Drive the air conditioning compressor off of the electric traction motor with a gear or belt drive, instead of using a separate electrically-driven compressor.

3. Conclusion

Hybrid-electric vehicles (HEVs) combine the benefits of gasoline engines and electric motors and can be configured to obtain different objectives, such as improved fuel economy, increased power, or additional auxiliary power for electronic devices and power tools.

The transmission of power using freewheels and chain wheels is very cheap and reliable. Though this combined power train system can become much useful in more stop and go traffic situations. With the use of this powertrain system, the overall fuel consumption and fuel economy is improved. Such vehicle would run on fuel but would use its electric motor to boost the power when needed. The cost of HEVs are a little more than the conventional cars but they more efficient and the exhaust emissions are less.

References

[1] M. I. Marei, S. J. Samborsky, S. B. Lambert, M. M. ASalama. On the Characterization of Ultracapacitor BanksUsed for HEVs, Proceedings of the IEEE Vehicle Powerand Propulsion Conference, VPPC "06, Windsor, UK,2006, pp. 1-6.

[2] M. Barcaro, N. Bianchi, F. Magnussen. PM Motors for Hybrid Electric Vehicles. The Open Fuels & Energy Science Journal, Vol. 2, pp. 135-141, June 2009.

[3] T. Yaegashi. In Challenge of Achieving Sustainable Mobility through Hybridization, Research and Development of Hybrid Vehicles in Japan and Sweden Seminarim, Göteborg, Sweden, 2006.

[4] Zs. Preitl, P. Bauer, J. Bokor. Fuel Consumptionoptimization for Hybrid Solar Vehicle, Page: 11-18.International Workshop on Hybrid and Solar Vehicles.University of Salerno, Italy. November 5-6, 2006.

[5] Satti Swami Reddy, Kola Siva Tharun, Eco Friendly Vehicle, International Journal of Engineering Trends and Technology (IJETT), 4(4), April 2013, 957-960.

[6] Hasan K , Fuzzy Logic Controller for Parallel Plug-in Hybrid Vehicle Master thesis , University of Wisconsin Milwaukee, 2015.