Electric Vehicles Configurations: A Review

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Abstract

In the present scenario Global warming, decrement in conventional fossil fuels directing the researchers to an alternate to the transportation using electrical energy. This paper presents different types of electric vehicles hybrid electric vehicles (HEV), plug-in hybrid electric vehicle (PHEV), fuel cell electric vehicles (FHEV) and battery electric vehicle (BEV) based on the configuration of connecting electric propulsion system with or without the conventional IC engine and also the motors which are suitable for various traction applications. In fact this paper also aims to provide information of electric mobility, motors, battery system, advantages and disadvantages of electric vehicles. The methodology used in this paper is descriptive.

Keywords - *electric vehicle (EV), hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), fuel cell electric vehicle (FHEV) battery electric vehicle (BEV), configuration and traction.*

I. INTRODUCTION

In the year of 1832-1839 Scottish inventors Robert Anderson invents the first crude electric carriage powered by non-rechargeable primary cells. **1**859 French physicist Gaston Planté invents the rechargeable lead-acid storage battery. In 1881, his countryman Camille Faure will improve the storage battery's ability to supply current and invent the basic lead-acid battery used in automobiles. 1899 Believing that electricity will run autos in the future, Thomas Alva Edison begins his mission to create a long-lasting, powerful battery for commercial automobiles. Though his research yields some improvements to the alkaline battery, he ultimately abandons his quest a decade later. 1920 During the 1920s the electric car ceases to be a viable commercial product. The electric car's downfall is attributable to a number of factors, including the desire for longer distance vehicles, their lack of horsepower, and the ready availability of gasoline. 1970s Concerns about the soaring price of oil -- peaking with the Arab Oil Embargo of 1973 -- and a growing environmental movement result in renewed interests in electric cars from both consumers and producers [1]. Although the EV was around before the turn of the 20th century, the modern EV is a completely new vehicle that is totally different from the classical EV. It is not only a transportation vehicle, but also a new type of electric equipment. Even all governments are encouraging citizens to use the electric transportation in private and public sectors. The architecture or configuration of an EV defines the type of EV as below:

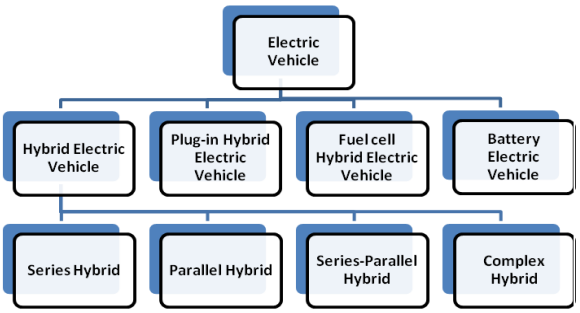

Fig.1: Types of Electric Vehicles

II. HYBRID ELECTRIC VEHICLE

What exactly is an HEV? The definition available is so general that it anticipates future technologies of energy sources. The term hybrid vehicle refers to a vehicle with at least two sources of power. A hybrid-electric vehicle indicates that one source of power is provided by an electric motor. The other source of motive power can come from a number of different technologies, but is typically provided by an internal combustion engine designed to run on either gasoline or diesel fuel. As proposed by Technical Committee (Electric Road Vehicles) of the International Electro technical Commission, an HEV is a vehicle in which propulsion energy is available from two or more types of energy sources and at least one of them can deliver electrical energy.

A. Series Hybrid EV

In case of series hybrid system (Figure 2a) the mechanical output is first converted into electricity using a generator. The converted electricity either charges the battery or can bypass the battery to propel the wheels via the motor and mechanical transmission. Conceptually, it is an ICE assisted Electric Vehicle (EV) [2]. The advantages of series hybrid drivetrains are:

- Mechanical decoupling between the ICE and driven wheels allows the IC engine operating at its very narrow optimal region as shown in Figure 2b.
- Nearly ideal torque-speed characteristics of electric motor make multi gear transmission unnecessary.

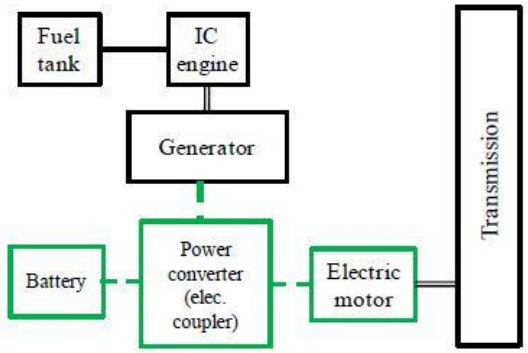

Fig.2a: Series Hybrid EV

However, a series hybrid drivetrain has the following disadvantages:

- The energy is converted twice (mechanical to electrical and then to mechanical) and this reduces the overall efficiency.
- Two electric machines are needed and a big traction motor is required because it is the only torque source of the driven wheels.

The series hybrid drivetrain is used in heavy commercial vehicles, military vehicles and buses. The reason is that large vehicles have enough space for the bulky engine/generator system.

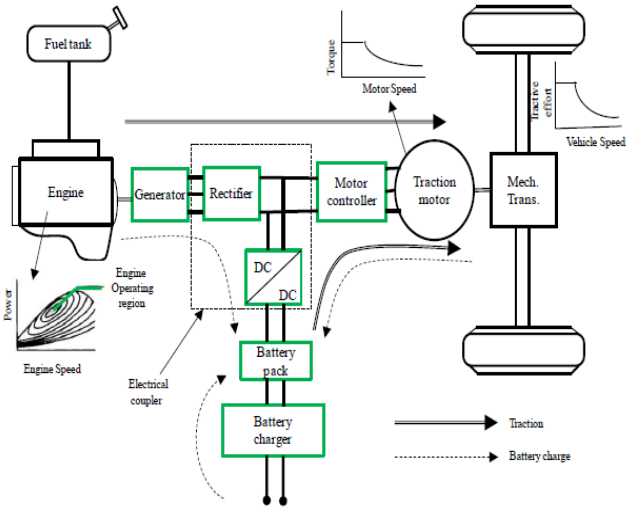

Fig.2b: Detailed Configuration of Series Hybrid EV

B. Parallel Hybrid

The parallel HEV (Figure 3a) allows both ICE and electric motor (EM) to deliver power to drive the wheels. Since both the ICE and EM are coupled to the drive shaft of the wheels via two clutches, the propulsion power may be supplied by ICE alone, by EM only or by both ICE and EM. The EM can be used as a generator to charge the battery by regenerative braking or absorbing power from the ICE when its output is greater than that required to drive the wheels [2]. The advantages of the parallel hybrid drivetrain are:

- Both engine and electric motor directly supply torques to the driven wheels and no energy form conversion occurs, hence energy loss is less.
- Compactness due to no need of the generator and smaller traction motor.

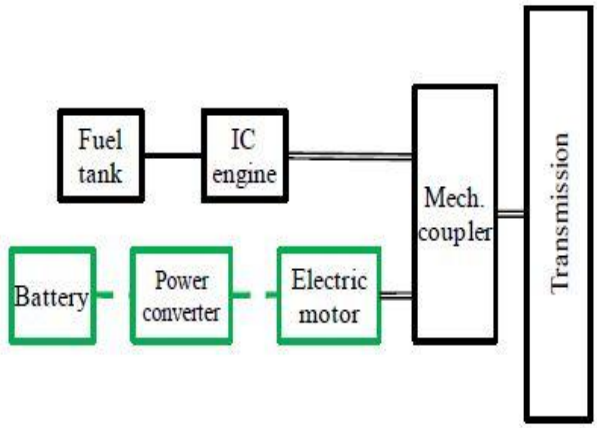

Fig.3a: Configuration of Parallel Hybrid EV

The drawbacks of parallel hybrid drivetrains are:

- Mechanical coupling between the engines and the driven wheels, thus the engine operating points cannot be fixed in a narrow speed region.
- The mechanical configuration and the control strategy are complex compared to series hybrid drivetrain.

Due to its compact characteristics, small vehicles use parallel configuration. Most passenger cars employ this configuration.

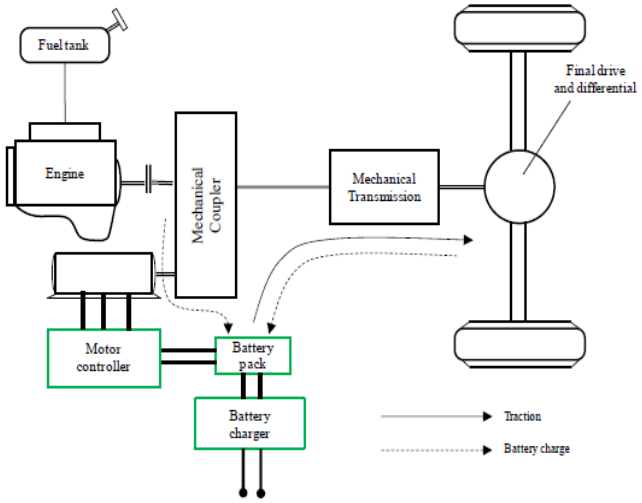

Fig.3b: Detailed Configuration of Parallel Hybrid EV

C. Series-Parallel Hybrid Electric Vehicle

In the series-parallel hybrid (Figure 4c), the configuration incorporates the features of both the series and parallel HEVs. However, this configuration needs an additional electric machine and a planetary gear unit making the control complex.

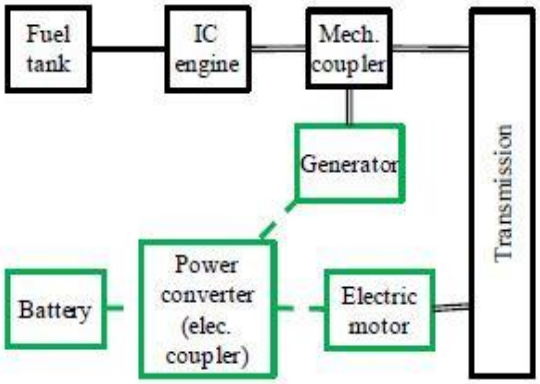

Fig.4a: Configuration of Series-Parallel Hybrid EV

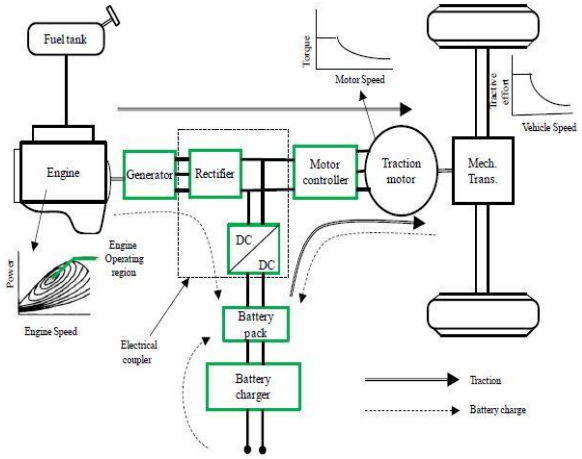

Fig.4b: Detailed Configuration of Series-Parallel Hybrid EV

D. Complex Hybrid Electric Vehicle

The complex hybrid system (Figure 4d) involves a configuration which cannot be classified into the above three kinds. The complex hybrid is similar to the series-parallel hybrid since the generator and electric motor is both electric machines. However, the key difference is due to the bi-directional power flow of the electric motor in complex hybrid and the unidirectional power flow of the generator in the series-parallel hybrid. The major disadvantage of complex hybrid is higher complexity.

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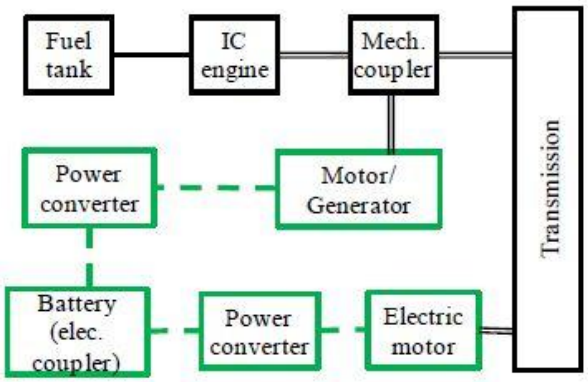

Fig.5: Configuration of Complex Hybrid EV complex

III.PLUG-IN HYBRID ELECTRIC VEHICLES

Plug-in hybrid electric vehicles (PHEVs) use batteries to power an electric motor and use another fuel, such as gasoline or diesel, to power an internal combustion engine or other propulsion source. Using electricity from the grid to run the vehicle some or all of the time reduces operating costs and fuel use, relative to conventional vehicles. PHEVs may also produce lower levels of emissions, depending on the electricity source [3]. And the PHEV also can be configured in four ways as the above mentioned hybrid electric vehicles.

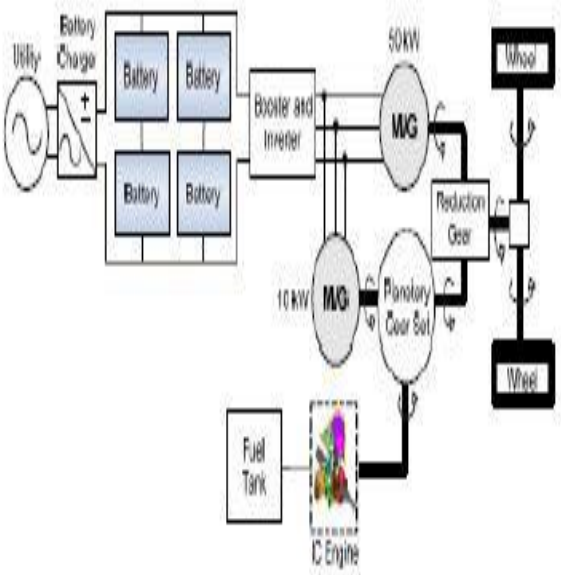

Fig.6: Configuration of Plug-In Hybrid EV

There are several light-duty PHEVs commercially available, and some medium-duty vehicles are now entering the market. Medium- and heavy-duty vehicles can also be converted to PHEVs. Although PHEVs are generally more expensive than similar conventional and hybrid

vehicles, some cost can be recovered through fuel savings or state incentives.

IV. FUEL-CELL ELECTRIC VEHICLES

In this electrochemical device, the reaction between a fuel, such as hydrogen, and an oxidant, such as oxygen or air, converts the chemical energy of the fuel directly into electrical energy. The fuel cell is not a battery and does not store energy, although the fuel cell also has two electrodes separated by an electrolyte. When fuel cells are the primary power source in a hybrid vehicle, batteries provide secondary power. Fuel cells do not provide immediate output during a cold start. Until the fuel cells reach operating

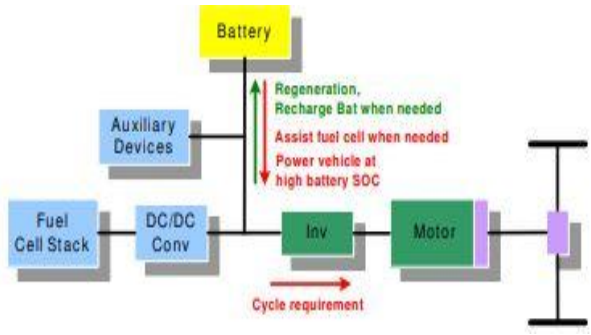

Fig.7: Configuration of Fuel-Cell Hybrid EV

temperature, which may take about 5min, a battery pack supplies the power for initial start-up and vehicle movement.

V. BATTERY ELECTRIC VEHICLES

A battery electric vehicle (BEV) runs entirely using an electric motor and battery, without the support of a traditional internal combustion engine, and must be plugged into an external source of electricity to recharge its battery. Like all electric vehicles, BEVs can also recharge their batteries through a process known as regenerative braking, which uses the vehicle's electric motor to assist in slowing the vehicle, and to recover some of the energyno normally converted to heat by the brakes [5].

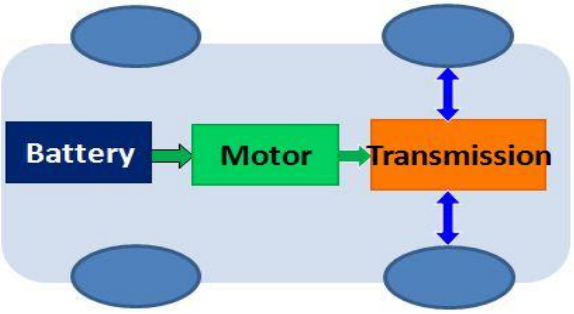

Fig.8: Configuration of Battery Hybrid EV

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