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Analysis of Hybrid Electric Vehicle Technologies

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Annotation: Demands for more efficient vehicles with reduced fuel consumption and low emissions are growing rapidly in these days. Generally, they can create a competition among automakers in the worldwide. In order to satisfy these kind of factors, using of hybrid electrical powertrains in vehicles can be regarded one of the solution. In this study, the background theories on different types of Hybrid Electrical vehicles (HEVs) are described precisely. The main purpose of this article to analyze advantages and disadvantages of every technologies and to research their efficiency.

Keywords: Hybrid electric vehicles, series hybrids, parallel hybrids, series-parallel hybrids, mild hybrids, full hybrids, plug – in hybrids.

INTRODUCTION

The term hybrid electric vehicle has two kinds of energy sources which are internal combustion engine and battery pack. In this type of electric vehicle, internal combustion engine gets energy from fuel while electric motor takes energy from battery. Three different types according to degree of hybridization and three types according to powertrain configurations are exist in HEVs.

HEVs are classified three categories according to degree of hybridization which are full hybrids, mild hybrids and full plug-in hybrids [1].

The full hybrid system use a bigger battery than mild hybrid system also a much bigger electric motor. Hybrid cars can be powered by only electric motors. Not only the fuel saving and less emissions are advantages of the full hybrids but also an internal combustion engine and an electric motor will work together to give the maximum power. Hybrid car can not be charged, they will charge automatically when the car will break and it will charge by the engine when the car running .Full hybrid vehicles is more expensive than mild hybrids but provide good fuel economy.

The vehicle is powered mild hybrid system have an ICE (diesel or petrol), an electric motor in a separate special battery. The main difference in mild hybrid system uses much smaller electric motor it more like a starter and also a smaller battery. The electric motor and battery can not power the vehicle itself, so without combustion engine vehicle will not move in hybrid mild system. However, it uses a battery and an electric motor can allow the engine to switch off when the vehicle stops (such as at traffic lights or in stop and go traffic) in order to save fuel consumption and reduce emissions. Main benefit and purpose of the system to achieve lower emissions and less fuel consumption. More mechanical pieces in the case of failure in the system is considered disadvantages of the vehicle.

The difference between PHEVs and HEVs lies primarily in the size of the battery capacity and the recharging method. A plug in hybrid electric vehicle (PHEV) has a much bigger battery and it can be charge by plugging a charging equipment, by the ICE or through regenerative braking. During braking, the electric motor works as a generator, using the energy to charge the battery. The vehicle works on electric mode until the battery nearly depleted, and then the car automatically switches over to use the ICE. The main advantage of plug in hybrid electric vehicle is an extended all electric range capability. In comparison with conventional vehicle, PHEVs can reduce operating cost and fuel use by using electricity from grid. Plug - in hybrid electrical vehicle have showed low fuel consumption and good performance. [2]

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HEV classification	Start/ Stop	Regenerative Braking	Power assist	Electric drive Capability
Mild HEV	Yes	Yes	Yes	No electric drive
Full HEV	Yes	Yes	Yes	Short electric drive
Plug-in HEV	Yes	Yes	Yes	Extended electric drive
Full Electric	Yes	Yes	No	Full electric drive

Figure 1. Classification and features of Hybrid EVs

Hybrid electrical vehicles are popular for their amplified efficiencies as compared to conventional vehicles. As said earlier, the electric motor and IC engine are mentioned propulsion systems for HEVs. The configurations of the HEV define how the electric motor works in conjunction with the ICE. The components can be connected by different architectures. Generally, three common design options of HEV architecture are exist:

i. Series hybrid electric vehicle
ii. Parallel hybrid electric vehicle
iii. Series – parallel electric vehicle

Series hybrid electric vehicles

The construction of series hybrid electrical vehicle is much simpler compared to other configurations. Series hybrid electrical vehicle is known as electrical coupling.

The main components of series HEVs are IC engine, generator, converter, battery pack and electric motor. The internal combustion engine is connected directly to the generator which the electric power is generated as well as the battery pack and generator connected to the electric motor which is mechanical power can be produced. In series hybrid vehicle, only the electric motor is responsible for vehicle driving. The difference with a pure electric vehicle is that the energy does not come exclusively from a battery recharged by the grid, but also the battery is charged partially or completely by an internal combustion engine.

In this type of the vehicle, the engine is used to generate only the electrical power it provides the engine works at its maximum efficiency. The control strategy is more simpler when compare with other configurations because there is mechanical coupling between engine and wheels

Series hybrids may also be referred to as extended-range electric vehicles (EREVs**) or** range-extended electric vehicles (REEVs) since the gas engine only generates electricity to be used by the electric motor and never directly drives the wheels. Modern examples include the Cadillac ELR, Chevrolet Volt, and Fisker Karma.

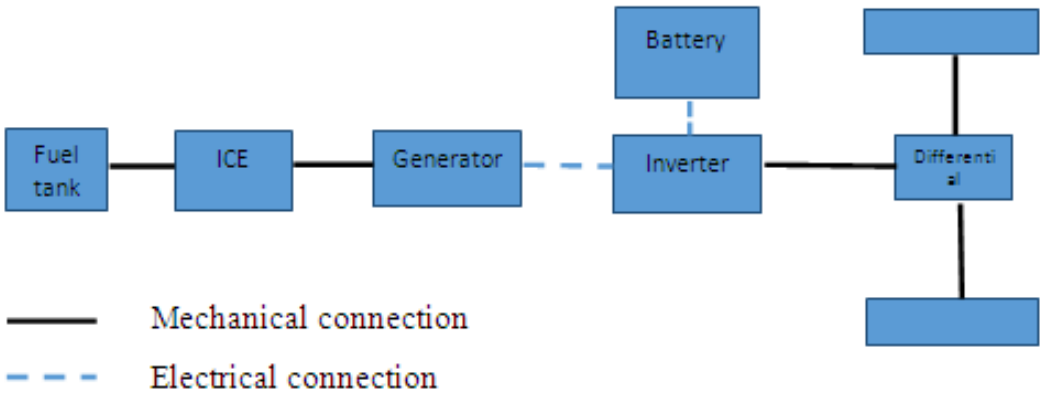

Figure 1.2. Series hybrid electric vehicle configuration

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Parallel hybrid electric vehicles

The hybrid electric vehicle with equipped parallel hybrid configuration can be moved by both an internal combustion engine and an electric motor connected to the wheel as shown in Figure 2.2. The powers from electric motor and ICE are merged together with the help of mechanical coupling. The electric motor can be used in low speed condition. Thus at higher speed, this set up allows the engine to work in its ideal operating range with high efficiency [3]. When the vehicle is propelled only with the EM, the engine can be decoupled, whereas on the other hand, when the ICE is driving the vehicle, the EM is connected and it can be utilized as a generator to charge the battery by regenerative braking or by power provided by the ICE.

The parallel hybrid vehicles can divide into 4 classifications according to the placement of the electric motor in conventional powertrain [4]:

1. Micro hybrids, the EM can be arranged as belt driven or crankshaft before ICE, for this reason, its speed is linked to the engine.
2. Pre-transmission parallel hybrids, the EM can be mounted between the engine and the gearbox.
3. Double-shaft parallel hybrids, the EM can be placed downstream of the gearbox
4. Double drive parallel hybrids, where the ICE can be placed on the other shaft separately from the EM.

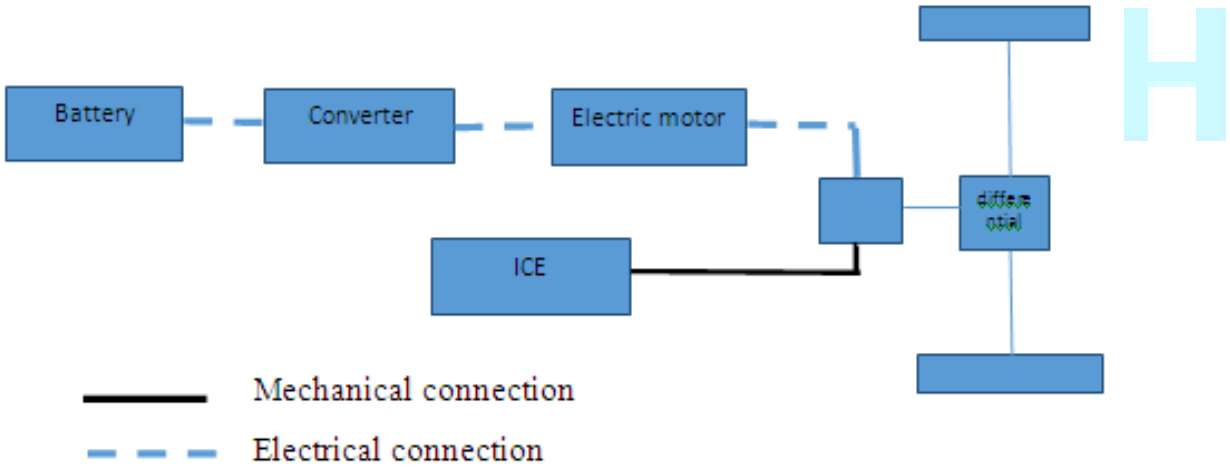

Figure 1.2. Parallel hybrid configuration

Series – parallel hybrid configuration

Series – parallel hybrid vehicles is also called power – split hybrids are parallel that include power-split devices. It allows for power paths from the ICE to the wheels on the mechanical or electrical way. This configuration combines the best aspects of series and parallel hybrids in order to create an extremely efficient system. In contrast with these technologies, power – split hybrid requires more components and a more complex control algorithm. The power which can be produced by the engine splits to the generator in order to generate electricity, on other hand to the mechanical gear system to propel the vehicle. The architecture of power – split hybrids are shown in Figure 1.3.

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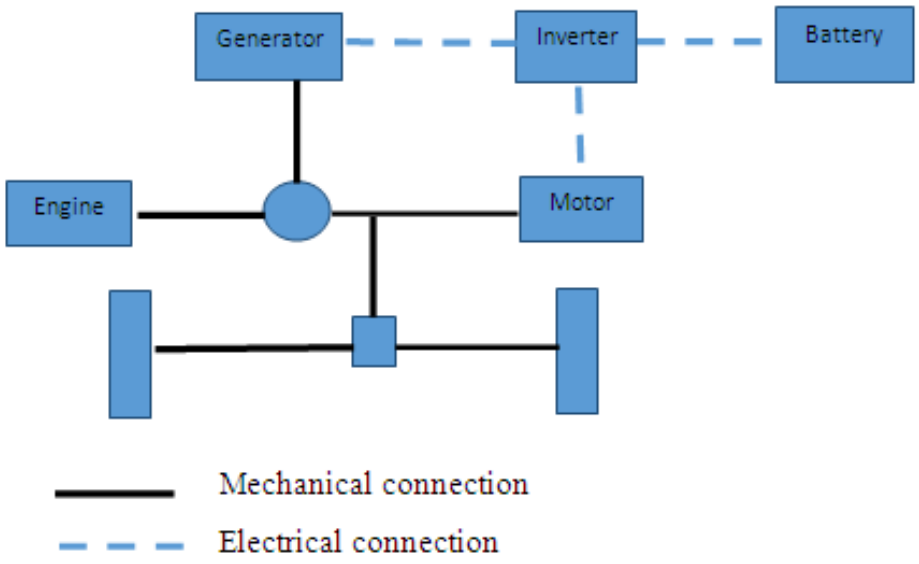

Figure 1.3 Series – parallel hybrid configuration

According to Hybrid Center [5], the composition of parallel hybrids makes them more efficient for highway driving at high and more constant speeds. Conversely, series hybrids are more effective for driving in the city because their drivetrain structure reduces the strain on the engine in stop-and-go driving situations.

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