LESSON 10

Electric Vehicles

LWPS2

LEARNING OBJECTIVES

The objectives of this lesson is to know about electric vehicles and its components, plug-in hybrid vehicles, fuel cell vehicles, types of hybrid vehicles, energy storage of electric vehicles and energy management system.

In modern trend, the vehicles manufacturing is based on the electric supply as the source of energy. On that basis the scope of the unit has been presented to balance the fuel cost.

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10.1 INTRODUCTION

Electric Vehicles (EVs) are the vehicles that are either partially or fully powered on electric power. Electric vehicles have low running costs because they have fewer moving parts for maintenance and are environmentally eco-friendly. Consequently, electric vehicles are the only zero-emission vehicles (ZEVs) possible.

On-road, electric vehicles include electric cars, electric buses, battery electric buses, electric trucks, electric bicycles, electric motorcycles and scooters etc. Off-road vehicles include electrified all-terrain vehicles and tractors. In the year 1827, the first car powered by an electric motor was launched.

Comparison of conventional internal combustion engine (IC) vehicles to Electric vehicles

S.No.	Internal combustion engine vehicles	Electric vehicles
1	Power train: Internal combustion engine	Powertrain: Electric motor
2	Fuel: Petrol or Diesel	Fuel: Battery
3	Running cost is high	Running cost is low
4	Noisy while operation	Quiet during operation
5	Emits greenhouse gases	Emission free
6	Refilling is easy	Lacks in charging

10.2 TYPES OF ELECTRIC VEHICLES

1. Battery electric vehicles
2. Hybrid electric vehicles/Plug-in hybrid electric vehicles

10.2.1 Battery Electric Vehicles (BEV or EV)

The concept of the battery electric vehicle or simply electric vehicle is essentially simple and is shown in Figure 10.1. An electric vehicle consists of

1. Battery - that provides electric energy,
2. Electric motor - that drives the wheels through transmission.
3. Controller - that regulates the energy flow to the motor.

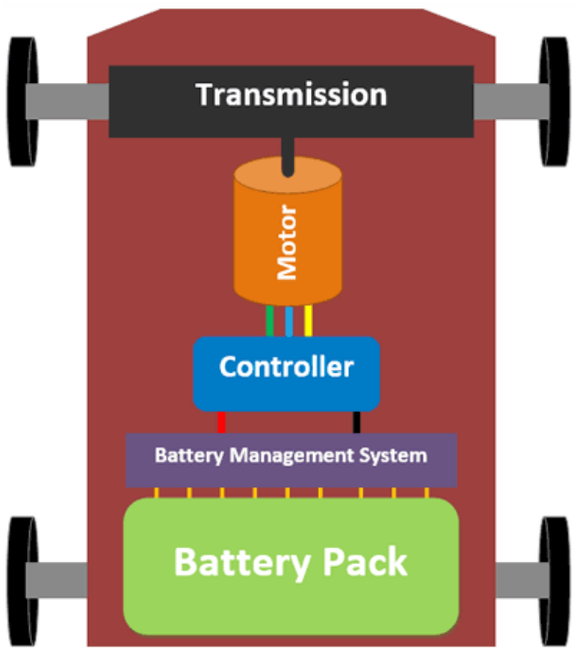

Fig.10.1 *Lay-out diagram of Electric vehicle*

1. Battery

Batteries are the fuel source for an electric vehicle. It provides electric energy needed by the electric motor. The battery must be designed based on the rating of the motor and charging system that a vehicle utilizes. Different types of rechargeable batteries are available now which includes lead-acid, nickel metal hydride, and lithium-ion batteries that recharging is taking place while the vehicle is in movement.

a. Lead-acid battery

The lead-acid batteries are made with lead. It is a rechargeable battery and has relatively low energy density. Lead-acid batteries can be designed to be high power and are inexpensive, safe, and reliable.

Fig.10.2 *Lead-acid battery*

b. Lithium-ion battery

The fig 10.3 is shown a Lithium-ion battery is a type of rechargeable battery used in electric vehicles and portable electronic equipments. It is having higher energy density than typical lead-acid or nickel-cadmium rechargeable batteries.

Fig.10.3 *Lithium-ion battery*

2. Electric motor

In electric vehicles, the electric motor is the only device which converts electrical energy into mechanical energy. Batteries are the fuel tanks of an EV, the motors are the Engines of them. There are many types of motors used for scooters, bikes and cars is totally different form the one another. The commonly used electric vehicles are brushless DC (BLDC / HUB) motors, brushed DC motors and AC Induction motors. The fig 10.4 shows the exploded view of electric vehicle motor.

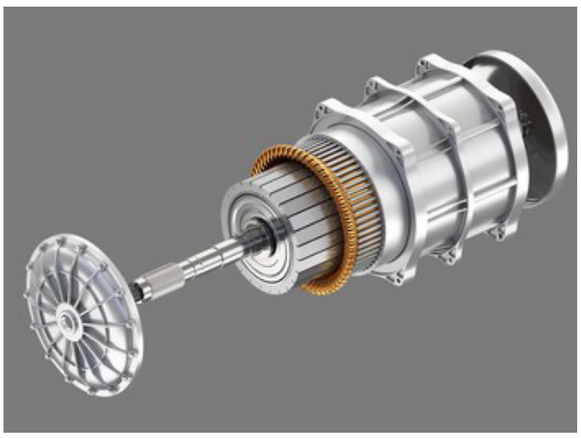

Fig.10.4 *Electric motor*

AC motor is less expensive and lighter in weight. But the DC motor has a simple controller, making the combination

less expensive. The main disadvantage of the AC motor is the cost of the electronic package needed to convert (invert) the battery's direct current to alternating current for the motor.

The DC motor and controller system is still used today in some electric vehicles to keep the cost cheaper. However, with the advent of better and less expensive electronics, a large number of today's electric vehicles are using AC motor and controller systems because of their improved motor efficiency and lighter weight.

3. Controller

The electric vehicle controller is having the electronics package that operates between the batteries and the motor to control speed and acceleration.

The controller transforms the battery's direct current into alternating current (for AC motors only) and regulates the energy flow from the battery.

Unlike the carburettor, the controller will also reverse the motor rotation (so the vehicle can go in reverse), and convert the motor to a generator (so that the kinetic energy of motion can be used to recharge the battery when the brake is applied).

The main operation of controller is seen from the diagram fig 10.5 shown below.

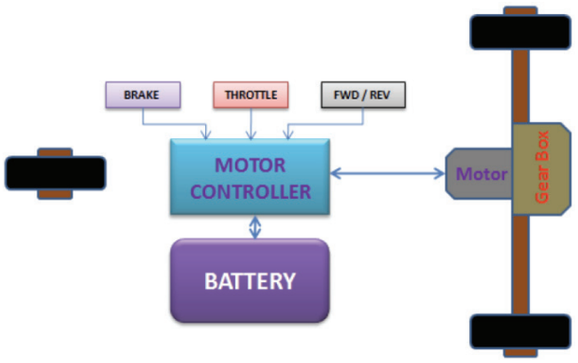

Fig.10.5 *Electric vehicle controller*

10.3 HYBRID ELECTRIC VEHICLES

Hybrid electric vehicles consists of various types and the degree to which each function as an electric vehicle also varies. The most common form of HEV is the hybrid electric car, although hybrid electric trucks, buses, boats and aircraft also exist.

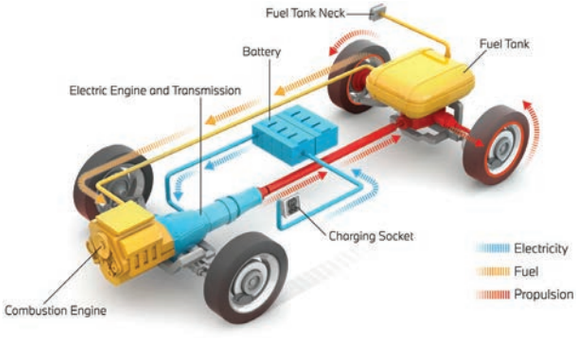

Fig.10.6 *Componentes of Hybrid electric vehicles*

10.3.1 Plug - in Hybrid Vehicle

A plug-in hybrid vehicle consists of both a combustion engine and an electric motor. Each one is capable of powering the vehicle on its own. Plug-in hybrid use regenerative braking as their energy source, but they can also be plugged in to recharge the battery.

Plug-in hybrid electric vehicle have both engine and electric motor to drive the car. Like regular hybrids, they can recharge their battery through regenerative braking. They differ from regular hybrids by having a much larger battery, and being able to plug into the grid to recharge. The battery pack in a PHEV is generally larger than in a standard hybrid electric vehicle. The larger battery pack allows the vehicle to operate predominantly on electricity during short trips.

For longer trips, a PHEV can draw liquid fuel from its onboard tank to provide a driving range similar to that of a conventional vehicle. An onboard computer decides which fuel should be used when, depending on the mode which the vehicle operates most efficient in.

The battery can be charged by plugging into an electric power source, through regenerative braking, and by the internal combustion engine. In regenerative braking, kinetic energy normally lost during braking is captured and stored in the battery.

10.3.2 Fuel Cell Electric Vehicles (FCEV)

How a fuel cell electric vehicle works?

Cars powered by hydrogen are considered as electric vehicles, because oxygen and hydrogen are converted to electric energy, which then powers the electric motor with a battery. It recaptures the energy that is lost during braking and stored again it in a battery.

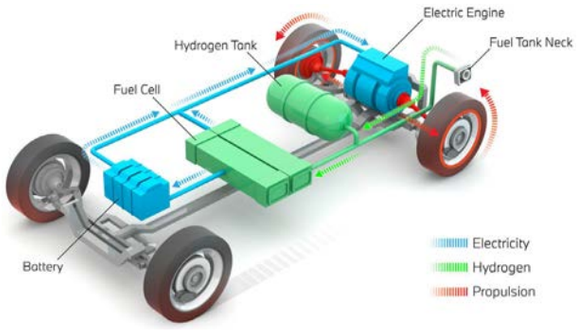

Fig.10.7 *Components of Fuel Cell Electric Vehicles*

Fuel cell electric vehicles create their own electricity on board. Hydrogen in the fuel cell reacts with oxygen in the air, thereby generating electricity, which is used to power the electric motor, similar to a battery electric vehicle. As a result, they emit water vapour and warm air. The production of hydrogen requires a large amount of electricity is an ecological disadvantage in it. On the top, the hydrogen must be transported to petrol stations.

Fuel cell electric vehicles have a range similar to that of future battery-powered electric vehicles. An advantage of this is, it takes short time to fill the tank just like a petrol / diesel car. In future, there would be having a little difference between operating a fuel cell electric vehicle and a petrol car.

It is also expensive to manufacture fuel cell systems. Because platinum is needed for the catalytic converter.

10.4 DRIVE TRAIN

A drive train is the combination of components that deliver power from a motor to the vehicle's wheels.

In hybrid-electric vehicles, the drive trains design how the electric motor works in conjunction with the conventional engine. The drive train affects the vehicle's mechanical efficiency, fuel consumption, and purchasing price.

There are three types of drive trains

1. Series drive trains
2. Parallel drive trains
3. Series / parallel drive trains

10.5 SERIES DRIVE TRAINS

Hybrids that use a series drive train only receive mechanical power from the electric motor, which is run by either with battery or a gasoline-powered generator.

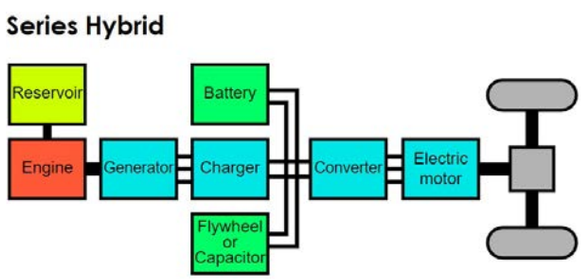

Fig.10.8 *Block diagram of series drive trains*

10.6 PARALLEL DRIVE TRAINS

In hybrids with parallel drive trains, the electric motor and internal combustion engine can provide mechanical power simultaneously.

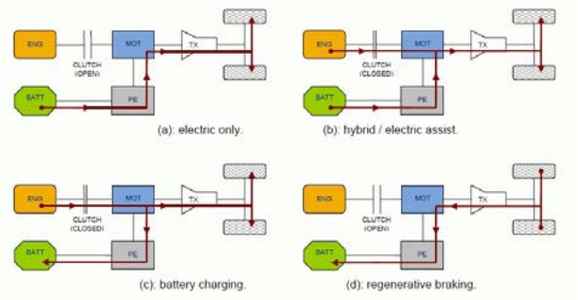

Fig.10.9 *Block diagram of parellel drive trains*

10.6.1 Series / parallel drive trains

Series / parallel drive trains enable the engine and electric motor to provide power independently or in contact with one another.

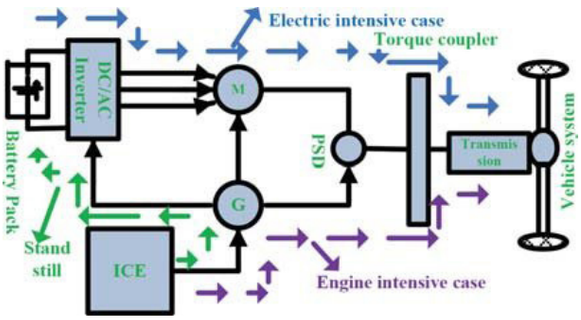

Fig.10.10 *Block diagram of series parellel drive trains*

10.7 ENERGY STORAGE AND ENERGY MANAGEMENT SYSTEM

(a) Energy storage

The evolution of energy storage and management systems along with more efficient motor were needed to replace the polluting and complex internal combustion engine.

Pure electric vehicles adopt a variety of benefits like...

a. Simpler and reliable infrastructure
b. Cheaper and less maintenance
c. Low transportation cost
d. Full power available at entire RPM range
e. Taxes reduction through subsidies

An electric vehicle can charge 80% power from house plug-in.

(b) Energy management

The energy management systems include all the various ways used to reduce cost, weight, and energy consumption while simultaneously increasing range and reliability. Hybrid energy storage describes the current prerequisites for the adoption of electric vehicles. Despite the fact that numerous techniques and controlling modules have ageing, over sizing, and power losses, consider driver behaviour, traffic, storage characteristics, and power splitting. As a result, the life of the battery and efficiency will be increased.

The availability of latest technologies such as Plug-in hybrid electric vehicle or Fuel cell vehicle, pure electric vehicles have the highest efficiency ie 67% as power output.

Now-a-days in latest technologies, we are using the ultra capacitors to lower the temperatures and minimized peak current. So we are getting the reduced power losses. Hence the operational cost is very less.

Hybrid energy storage systems can be created by combining multiple energy storage units. The energy storage system consists of a battery and an ultra capacitor. While the battery requires energy for a long time, the ultra capacitor can compensate the instant power demands.

The types of energy storage technologies are

a. Gravity energy storage
b. Flywheel energy storage
c. Superconducting magnetic energy storage systems.

In future, Gravity energy storage system with high-capacity energy storage will be assigned as new technology.

GLOSSARY

Predominantly — பெரும்பாலும்

PART A

Mark 1

Choose the correct answer:

1. In what year was the first car powered by an electric motor?
   a) 1911
   b) 1827
   c) 1962
   d) 1899
2. What percentage of electrical vehicle charging happens at home?
   a) 50%
   b) 75%
   c) 80%
   d) 90%
3. Which of the following is not type of hybrid electric vehicle?
   a) Plug-in hybrid
   b) Series hybrid
   c) Parallel hybrid
   d) Natural gas for vehicles
4. The hybrid electrical vehicles consists of
   a) internal combustion engine and electric motor
   b) two electric motor
   c) natural gas vehicle engine and electric motor
   d) petrol engine and electrical motor
5. Which battery is used electrical vehicles?
   a) Lithium-iron battery
   b) Lead-acid battery
   c) Dry cell
   d) Voltaic cell
6. What voltage is likely to be available from the battery of an electric and hybrid vehicle?
   a) 12 v
   b) 300 v
   c) 40 v
   d) 55 v
7. The _____ regulates the energy flow to the motor in battery electric vehicles
   a) controller
   b) battery
   c) petrol
   d) power supply
8. In regenerative braking _____ normally lost during braking and stored in the battery.
   a) Mechanical energy
   b) Kinetic energy
   c)Electrical energy
   d) Chemical energy

9. Pure electric vehicles are having the highest efficiency of _____
   a) 47%
   b) 57%
   c) 67%
   d) 77%

10. How many type of energy storage technology consists of?
    a) 3
    b) 5
    c) 7
    d) 9

PART B

Mark 3

Answer the questions in briefly

1. What is called an electric vehicle?
2. State hybrid electric vehicles.
3. List out the types of electric vehicles?
4. What are the difference between electric vehicle and hybrid electric vehicle?
5. What is drive train?
6. State lithium-iron battery.
7. What are benefits of pure electric vehicles.

PART C

Mark 5

Answer the questions not exceeding one page

1. Explain controller of electric vehicles
2. Explain series and parallel hybrid drives with schematic diagram.
3. Explain the energy management system of an electric vehicle.

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Explain and draw the schematic diagram of battery electric vehicle.

Reference book

1. 'Electric & Hybrid Vehicles' by AK Babu, Khanna Book Publishing Co (p) Ltd