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Modern Inventories and Environmental Impact of Electric vehicle

B.Vinoth kumar[1], Dr.P.Avirajamanjula[2]

[1]Department of Electrical and Electronics Engineering, PRIST University, Thanjavur, India.
[2]Department of Electrical and Electronics Engineering, PRIST University, Thanjavur, India.

Corresponding Author:
B. Vinothkumar
Department of Electrical and Electronics Engineering, PRIST University, Thanjavur, India.
Email: bpvinoth@gmail.com

ABSTRACT

Many new inventions are leading to significant changes in the automotive industry. Conventional vehicles have high-speed operation, high energy exposure and extended driving range. But Millions of conventional vehicles in use, emit high levels of carbon dioxide, due to this greenhouse gases in the atmosphere increases. So, the world is also facing natural disasters such as global warming. Thus, many countries are encouraging the vehicle to be powered by green energy. Due to the high use of fossil fuels, its stock is declining.Many researchers are exploring the technical challenges and opportunities in the electric vehicle. This article describes in detail the functional structure and performance of different types of electric vehicle.

Keyword: Electric vehicle, Plug-in Hybrid Electric Vehicles, Energy Management, Battery, Power converter, Motor, Component Sizing, Driving Cycles

1. INTRODUCTION

The Transport system plays an important role in the development of the country. In most of the countries, number of vehicles also increases year by year. All the vehicles are equipped with a combustion engine, they emit more polluted air like carbon dioxide, hydrocarbons, carbon monoxide, and nitrogen oxides. As a result of which the temperature of the atmosphere continues to accumulate with the pollutant in the air. As per the recent survey, greenhouse gas are increases by 33%, due to toxic gas from vehicles. So, it is very important to find an alternative way. All the automobile companies have done a lot of research for this. Electric vehicle is rapidly gaining interest of user, because it having more features compare to conventional vehicle. The features of low operating cost more customization flexible, zero emission, smooth operating condition, less noise, efficiently low maintenance.

1.1. HISTORY OF ICE

In 1860, Jean Joseph Etienne Lenoir developed and patented a commercial cylindrical internal combustion engine. After the long research Nikolaus A. Otto built successfully the most famous four stroke engine, known as the "Otto cycle “in 1876. 1886 - Karl Benz received the first patent for a gas- fueled car. The model of IC vehicle as shown in Figure.1.

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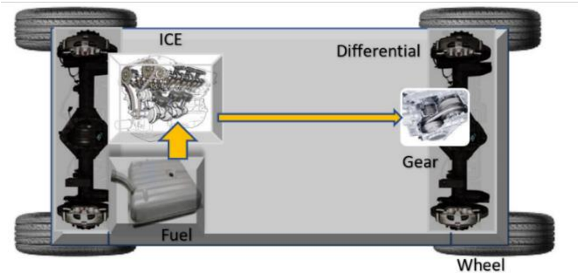

Figure.1. Internal combustion engine vehicle

Internal combustion engine-based vehicle is, fueled by the combustion of fossil fuel [1]s. In the conventional vehicle fossil fuel have not been fully converted in to efficient energy. In this type of vehicle 68% to 72% of energy is lost due to friction and exhaust heat. Similarly, due to parasitic and idle loss cause energy loss from 4% to 7%. Compared to internal combustion engine vehicles, electric vehicles, the energy loss is very low. In electric vehicle fuel efficiency is 95% will be obtained.Even the power conversion loss is 22%, the overall efficiency is 73% possible depends upon type of electric vehicle.

2.MODERN ELECTRIC AND HYBRID VEHICLE

2.1. Battery Electric vehicle

Research on electric vehicles have been going on since the 1830s. The electric vehicle has undergone many changes over the last hundred years. In 1939, Roberts Anderson designed their first electric vehicle. However, electric vehicles did not perform as well as IC vehicles at that time. Mainly the specific energy of diesel is 12600 wh/kg but Li-ion battery specific energy is 360 wh/kg. Battery capacity in electric vehicles was very low and its price was too high at that time and propulsion motor performance also not good, charging station infrastructure was difficult [2]. Due to this many reason, including the inability to travel long distances Electric vehicles gradually disappeared from the market. The automobile Industries, also facing has lot of technical challenges in electric vehicle development for efficient operation. After 1950, many outstanding new inventions in the field of Power electronics engineering sector faced many changes. The development of power electronics has revolutionized the automotive industry. The automobile Industries, also facing has lot of technical challenges in electric vehicle development for efficient operation.

The goal of this paper is to create a perspective view on electric vehicles. This paper describes the various types of electric vehicles on market, the configuration of the EV. The sizing of electric vehicles varies depending on the needs of the customer. This article describe the new opportunities and challenges in the electric vehicle industry like Smart grid technology, energy management, new business model etc.,

In Electric vehicles, electrical energy is converted into kinetic energy. The performance of the electric motor is 72 percent higher compared to the IC Engine [3]. The electric vehicle consists of a battery, power converter, electric motor. The model of electric vehicle as shown Figure.2. The electric vehicle has fewer parts compared to conventional vehicles, so the electric vehicle system is much easier to control and operate. The performance of an electric vehicle depends on the capacity of the battery because the battery is act as main source for EV. But in practice, the price and mass of the battery is very high for high capacity battery according to conventional vehicle distance coverage consideration. Due to these factors, the pure electric vehicle is not suitable for long distance travel. But EV is a highly efficient system for short distance travel. The tesla and Nissan -leaf model is available battery electric in the market.

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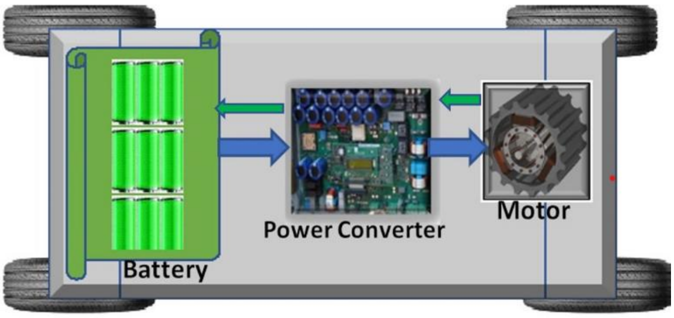

Figure.2. Battery Electric Vehicle

2.2. Hybrid electric vehicle:

Leading sales of vehicles that meet the needs of the customers. The most of the customers choose vehicle based on performance, price, maintenance cost and long-distance travel. But the electric vehicle is not suitable for long distance travel. The hybrid electric vehicle is the best vehicle compared to the electric vehicle and the IC engine vehicle [9]. This is because a hybrid vehicle is a combination of an electric vehicle and an IC vehicle as shown in Figure.3. Thus it, having the advantage of these two vehicles. Due to different operating mode of HEV, can obtain high efficiency, high performance and long-distance travel. Depending on the size of the vehicle, the hybrid vehicle can be divided into three types: mild hybrid, medium hybrid and fully hybrid.

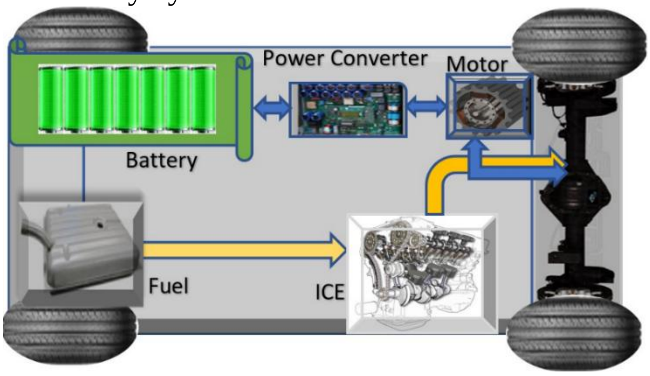

Figure.3.Hybrid Electric Vehicle

2.1.A. Series electrics vehicle:

The electric motor provides the propulsion required for a series hybrid vehicle. The electric motor get, the electrical energy from the battery through the configurated converter. This Configured system is suitable for short distance travel. The model of the Series-Hybrid electric vehicle as shown in figure.4.This vehicle is unable to meet the energy requirement when traveling long distances [5] . So, Now IC Engine assist electric motor by provide the mechanical power to the generator, It converts the mechanical power into electricity and stores the energy in the battery through the DC/DC Converter.

Mode of operation	Electric Propulsion	IC Engine Propulsion
Start	ON	OFF
Stop	ON	OFF
Short Distance Travel	ON	OFF
Long Distance Travel	ON	ON
Regenerative operation	ON	OFF

Table.1.Series electrics vehicle

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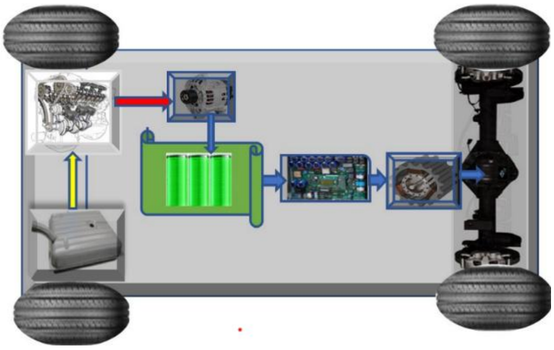

Figure.4. Series Hybrid Electric Vehicle

2.1.B. Parallel electric vehicle

The combined drive system of electric drive and IC engine drive are providing the required propulsion power to the vehicle. The model of the parallel electric vehicle as shown in figure.5. The driving force of a hybrid vehicle varies according to the stages of motion. The vehicle requires less propulsion power at the start and stop stages. In these two stages, the electric motor drive manages the movement of the vehicle. HEV required more driving force for long distance travel, claiming hill, high speed mode of driving. The combination of electric motor and engine provides driving power to the transmission system.

Mode of operation	Electric Propulsion	IC Engine Propulsion
Start	ON	OFF
Stop	ON	OFF
High speed Driving	ON	ON
Short Distance Travel	ON	OFF
Long Distance Travel	ON	ON
Regenerative operation	ON	OFF

Table.2.Parallelelectrics vehicle

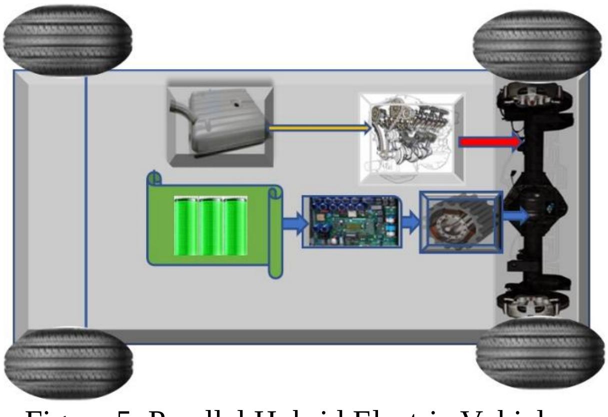

Figure.5. Parallel Hybrid Electric Vehicle

2.1.C. Series parallel electric vehicle

This type of system is an advanced technology of hybrid vehicle. This system configured by combination of series hybrid and parallel hybrid electric vehicle [8]. The model of the series parallel electric vehicle as shown figure.6. So, it has advantage of both series and parallel vehicle configuration. It is also possible to charge the batteries various levels, through that the loss of the system drastically reduced. The carbon dioxide emission is actually very low on these types of hybrid electric vehicles. This is an excellent advantage

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not found in other systems. However, due to the wide variety of components and different state of operation, their configuration of the system is very complex.

Mode of operation	Electric Propulsion	IC Engine Propulsion
Start	ON	OFF
Stop	ON	OFF
High speed Driving	ON	ON
Charging Battery	OFF	ON
Short Distance Travel	ON	OFF
Long Distance Travel	ON	ON
Regenerative operation	ON	OFF

Table.3.Series - Parallelelectrics vehicle

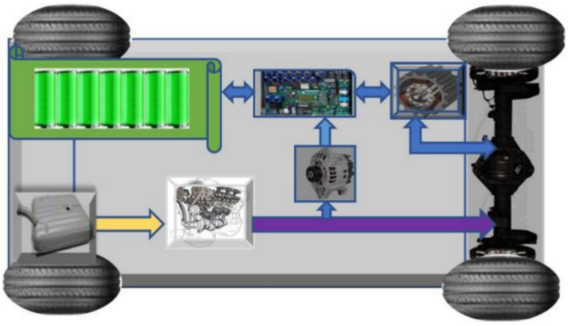

Figure.6. Series - Parallel Hybrid Electric Vehicle

2.1.D. Complex hybrid electric vehicle:

These types of vehicles are designed for high performance and high propulsion. Therefore, it is considered to be the most affordable and efficient vehicle [9] . So, it has a more complex configuration and technology. The model of the complex hybrid electric vehicle as shown in figure 7. This is suitable for a long travel, all types of roads and different modes of operation. Provides the driving force required for Hybrid vehicle under normal conditions such as idle, start, stop, traffic condition. In times of high energy required for high-speed travel, mountaineering and the combination of engine and electric motor provides the driving force required to the vehicle. Its special feature is that charging the battery with help of engine, generator, converter is possible at different stage.

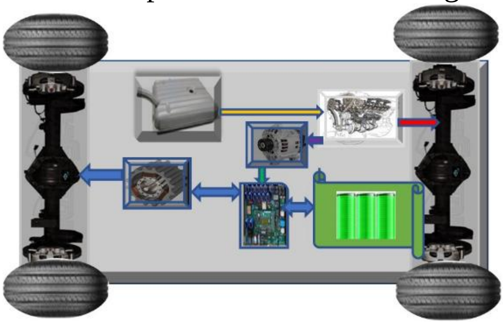

Figure.7. Complex Hybrid Electric Vehicle

2.3. Plug -in electric vehicle

The main difference between HEV and PHEV, the batteries of PHEV have external charging option. Most of the time the PHEV, is propelled by electric power train. Thus,

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minimizing the energy loss caused by the IC engine [12]. But it is not possible in the case of Hybrid electric vehicle. Because the battery in the hybrid vehicle did not have the facility of external charging. Due to this, energy enhancement is not so much better in hybrid electric vehicle. But energy management, high performance, greater distance travel is made possible through power train configuration and mode operation in PHEV as shown in Figure.8. Toyota Prius is successive running model of PHEV.

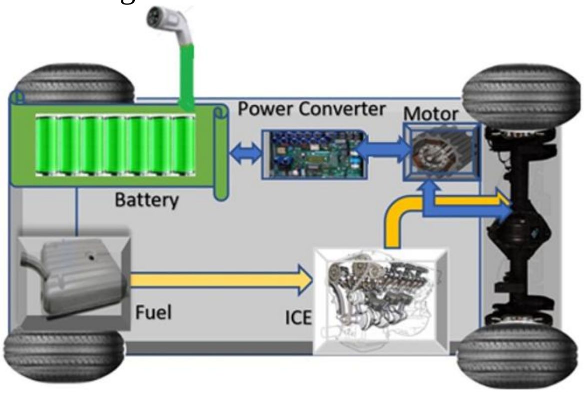

Figure.8. Plug -in Hybrid Electric Vehicle

2.4. Range extended electric vehicle:

The driving force required for the range extender electric vehicle is obtained by the battery. Also, the IC engine provides the driving power to the vehicle through the generator and battery [17]. It is a series hybrid drive train model, the main difference between full hybrid and rev is The IC engine size is downsized. Because the main propulsion drives electric motor, to extending the travel distance IC engine mechanical input drive the generator, to generate DC power. The model of the Range Extended electric vehicle as shown in Figure.9.

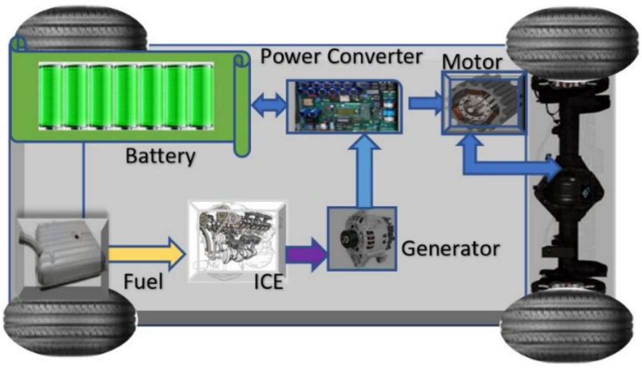

Figure.9. Range extender Electric Vehicle

2.5. Fuel cell hybrid electric vehicle:

In fuel cell stack is generate electricity by using a mixture of stored hydrogen and oxygen. The generated electricity power is used for the propulsion of the electric field [12]. The excess charge is stored in battery. The advantage of these method is that tailpipe emissions is 0% carbon and toxic gases.it only emit vapour and water in tailpipe. The technology has been improved through the last thirty years of research. The model of the FCHV as shown in figure.10. To refuel of vehicle takes four to five minutes, which allows it to travel longer distances, varying from 450 -580 depends on urban and highway drive cycle. Vehicle manufacturers are more interested in fuel cell electric vehicle production but these are not yet popular due to lack of awareness among the people about fuel cell technology. However, the Hyundai Tucson FCEV, Toyota Mirai, Chevrolet Equinox Fuel Cell are successful fuel cell electric vehicle in the market.

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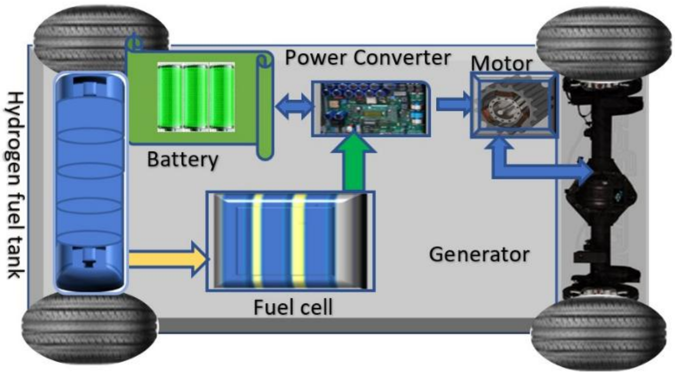

Figure.10. Fuel cell Electric Vehicle

3.POWER TRAIN CONFIGURATION

The configuration of Hybrid electric vehicle is based performance, fuel economy of vehicle will be varying. The electrical propulsion and engine propulsion have various option for sizing components as shown in figure 11,12,13.

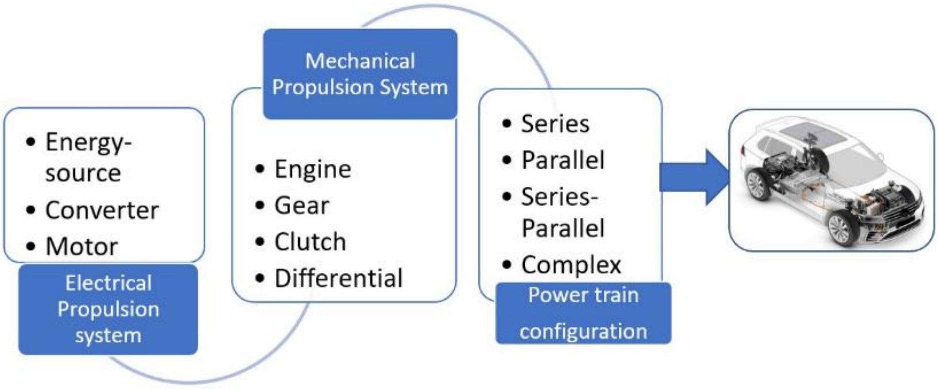

Figure.11. Configuration of power train

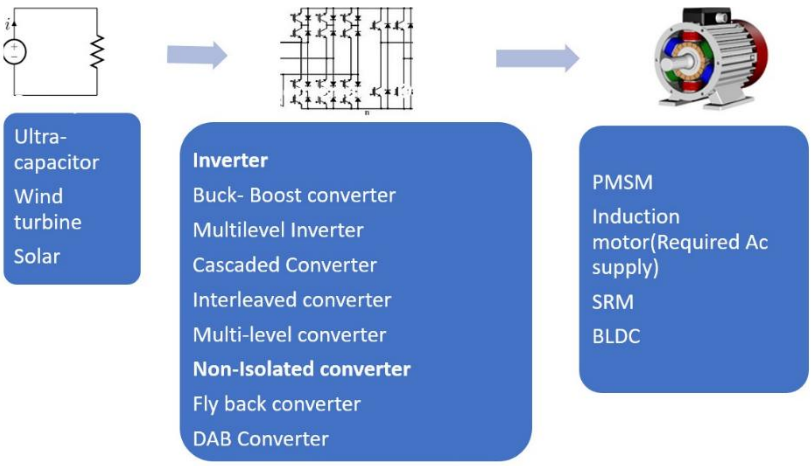

Figure.12. Configuration of electric power train

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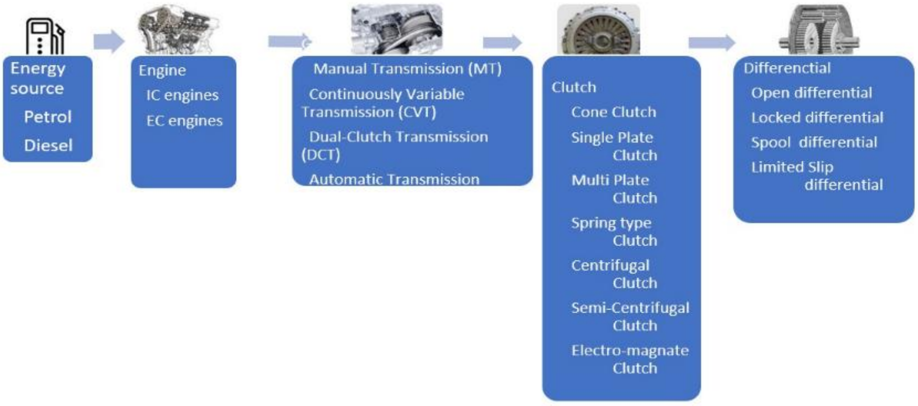
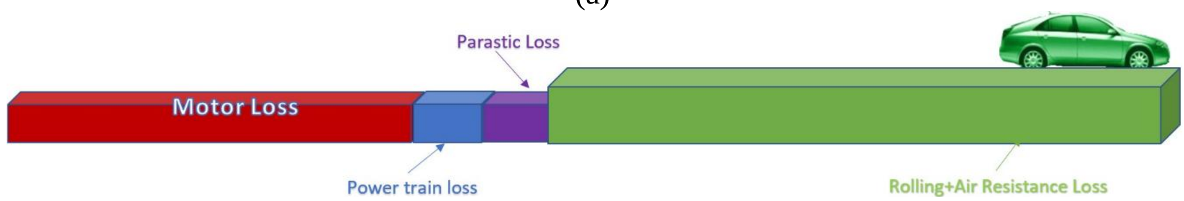


Figure.13. Configuration of Mechanical power train

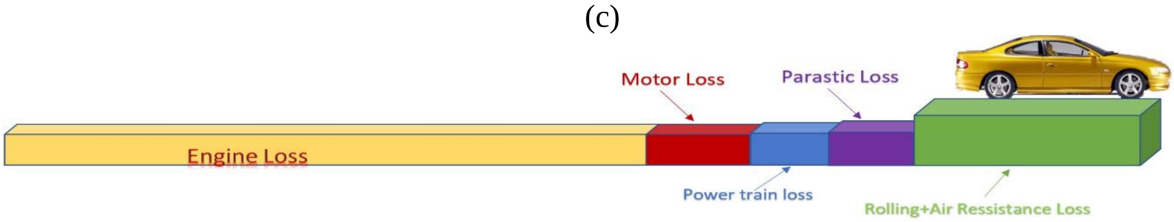
The conventional vehicle and various type of electric vehicle have the different loss. The major loss are IC Engine Loss, power train loss, parasitic loss, rolling and air resistance loss. For various type of conventional and hybrid vehicle loss figure out as follows:

(a)

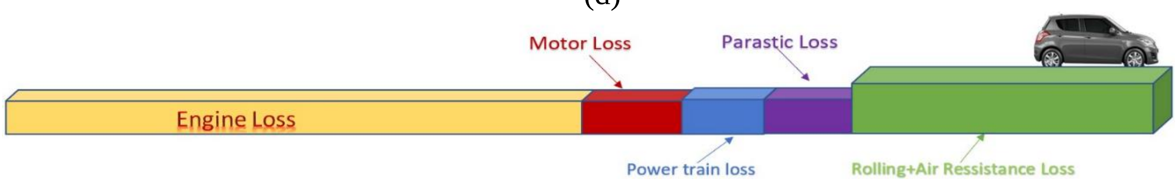


(b)

(c)



(d)



(e)

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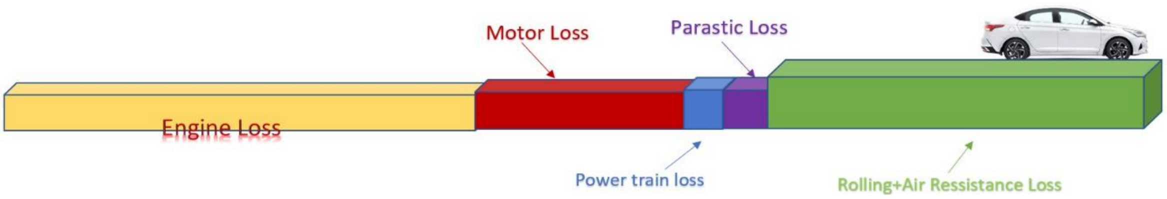
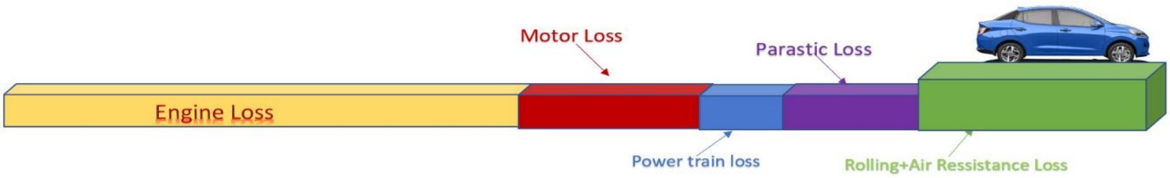
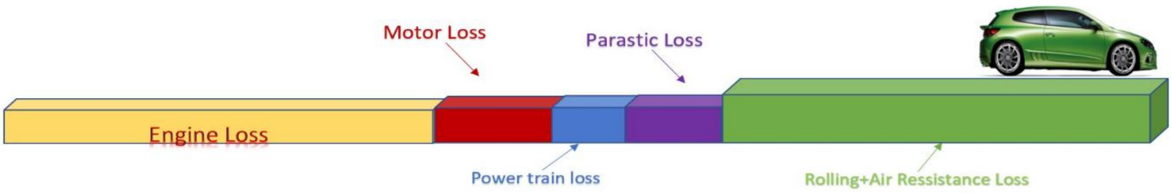


(f)



(g)



(h)

Fig 14 (a) ICV(b)BEV(c) Micro-HEV(d) Mild - HEV(e) FHEV(f) PHEV(g)FCEV(h)REV

3.1. ELECTRICAL DC/DC CONVERTER:

Electrical energy from the battery to the electric motor and other axillary components of vehicle. An electric vehicle can operate in many stages, in which the energy wasted while slowing down or descending a mountain. In this mode electric motor is operate in regenerative mode and convert kinetic energy to electric energy. This electric power is stored in battery with help of the bidirectional converter. This is feature of bidirectional converter compare to unidirectional converter [15]. The BDC is mainly classified two type, i.) Isolated converter 2.) Non -Isolated converter. It has many types of convert. The Size of the converter, power range, High efficiency, Low electromagnetic interference, Low ripple, Fast switching response are key factor for selection of converter.

DC/DC CONVERTER.

Isolated converter

Boost converter	Switched capacitor converter
Buck converter	Interleaved Boost converter
Cuk converter	Multi-level converter
Buck - booster converter	Cascaded converter
SPEIC converter	

Non- Isolated converter

Half bridge converter	Fly back converter
Full bridge converter	Multiport converter
Forward converter	Push pull converter
Dual half bridge	Dual active bridge
Cuk converter	

Table. 4. Power converter

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The mainly four type of converter is used for electric vehicle application are list below
1.Buck - Boost converter
2.Inter leaved Boost converter
3.DAB Converter
4.Multiport DAB converter

3.1.A. BUCK - BOOST CONVERTER

The buck boost converter name itself easily identified, it can operate in both buck and boost mode as per the load power requirement. The circuit topology as shown in fig(a) The boost mode operation occurs when traction motor operates in forward mode. The buck mode operation happens during the regenerating condition, the power low is possible from the motor to battery. It is mainly suitable for battery power system application [16]. The drawback of the converter, it is non-isolation converter.

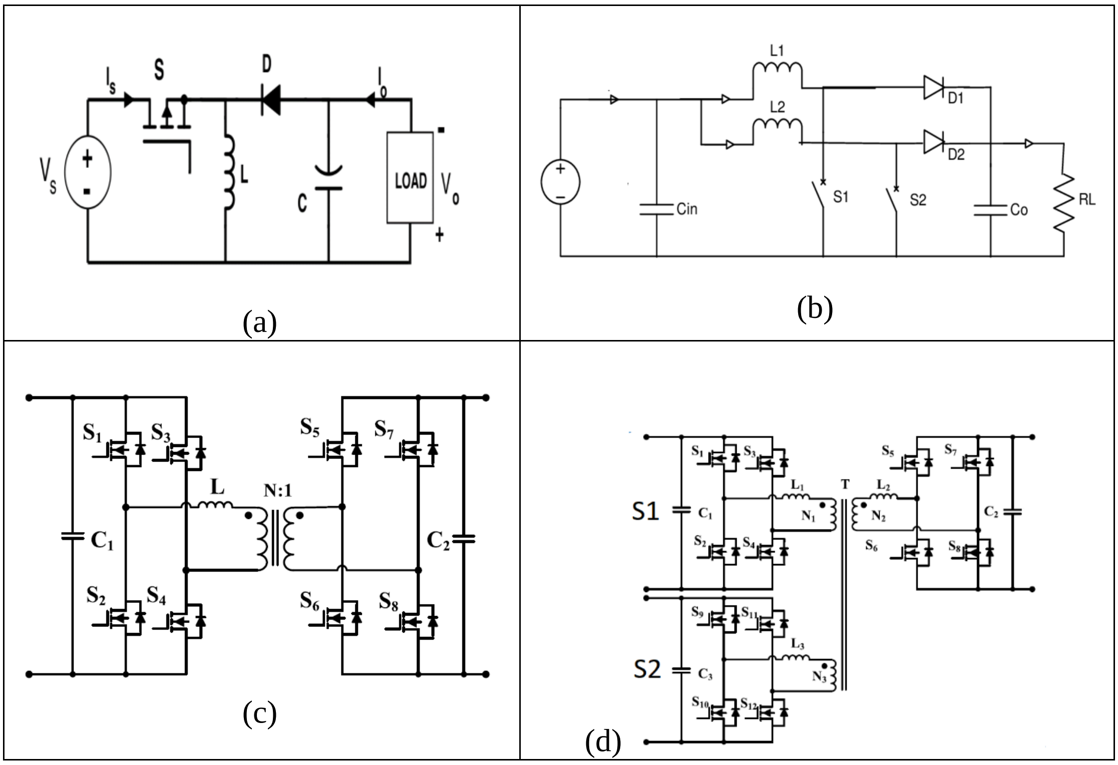

Fig 15 (a) Buck - Boost Converter(b) Inter Leaved Boost Converter (c) DAB Converter(d) Multiport DAB Converter

3.1.B. INTER LEAVED BOOST CONVERTER

It is type of non-isolation converter. Through the interleaved switch signal, this converter can achieve high efficiency. Due to low inductance in this topology as shown in fig (b), current ripple is very low compare to any other boost converter. In both continuous current mode and discontinuous current mode of operation fast switching transition will improve the performance of operation.

3.1.C. DAB CONVERTER

The galvanic isolated bidirectional converter is specifically suitable for electric vehicle, renewable energy source, aircraft and multisource application. In this topology, isolation between input and output port will increase the safety of the system.

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3.1.D. MULTIPORT DAB CONVERTER

The energy required for a hybrid electric vehicle varies at different levels [18] . The battery design required for this is more expensive and heavier[19]. So, type of converter required for managing power from different electric source at different load condition. The multi-port DAB converter is having multi input single output and transformer isolated configuration as show in fig (d) . The feature of this converter is high power density, Multi input, isolated converter and low cost.

Topology	Inductor	Capacitor	Switch	Features
Buck - Boost converter	1	1	2	Less number of components Low cost Low switching loss
Inter leaved Boost converter	2	2	4	Low ripple current Fast switching transition
DAB Converter	0	2	8	Isolated converter High power density
Multiport DAB converter	0	3	12	Isolated converter Manage different input

Table.5.Power converter

3.2.Motor

The electric motor is the main source of propulsion power in hybrid electric vehicles. Many types of electric motors have different performance, power, configuration, torque and efficiency.

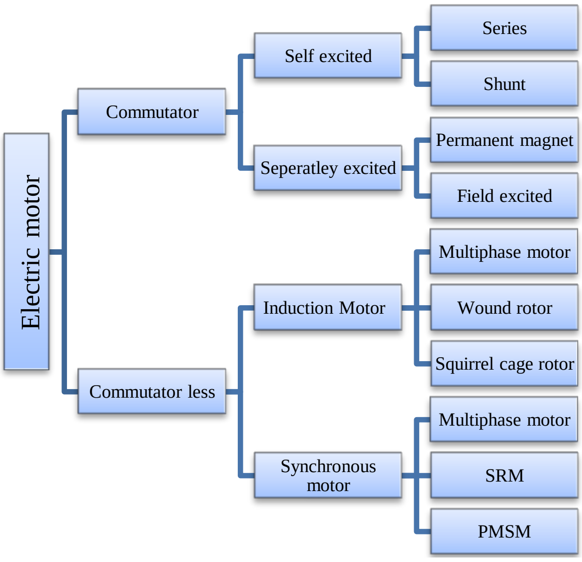

Fig. 16. Classification of Electric Motor

The four type of electric motors have the best function of delivering the required power at different levels in hybrid electric vehicles.

1)Permanent Magnet synchronous machine (PMSM)
2)Induction Motor (IM)
3)Switch reluctance Motor (SRM)
4)Brushless DC electric motor (BLDC)

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3.2.A. Induction Motor (IM)

Induction motor is dominant market leader in the field of electric propulsion drive. This motor is particularly suitable for wide range of speed control at various level. The combination of squirrel cage induction machine, high power density converter and FOC control will provide highly adaptable electric drive for EV, HEV and FCEV. High efficiency, wide range of control, low maintenance are the feature of Induction machine. The expensive controller, big size and High rotor loss are draw back of the induction machine [21].

3.2.B. Permanent Magnet synchronous machine (PMSM)

The PMSM is the combination of Induction and Brush less DC motorthe rotor is made up of permanent magnet it is the main difference between induction motor and PMSM. The field-oriented control is the popular control method for PMSM. This is Motor have the feature of high-power density, high torque, high speed operation, Low Nosie long life.

3.2.C. Switch reluctance Motor (SRM)

The SRM is variable reluctance motor, doubly salient with phase coils mounted around diametrically opposite stator poles. The simple control, high speed operation, Low maintenance, moderate cost compare to PMSM are the features of SRM. This mainly suitable for In-wheel motor application. The draw back of SRM is complex control, high noise and vibration.

3.2.D. Brushless DC electric motor (BLDC)

The BLDC drive have high efficiency is compare to any other type electric drive. The brushes and commutator are replaced by permanent magnet. So, BLDC have high compact, high reliable and controllable, low noise. It is also called as electronically commutated motor. The drawback of the BLDC is usage of rare earthed magnet, the cost of the motor is high and short constant power range.

3.3. Energy source technology

The traveling distance of electric vehicle purely depends on batteries range of the batteries. It is possible to travel longer distances by increasing the range of the battery. but as the range increases, so does its weight and price also increase[21-24]. Multi-source of power is energy supply is the best solution for this problem. The BMS technology will support the power balance between the electric drive and varies energy source like ultra-capacitor, solar etc.,

Batteries:

The batteries which one convert the electrochemical energy into electrical energy. The different type of battery technology is available for EV application. The selection of the batteries depends on the specific power, specific energy, cycle life, cost, charging time of batteries.

Type of Batteries	Nominal Voltage	Specific energy	Specific power	Life cycle	Memory effect
Lead acid	2.0	35-50	100-200	1000-1200	No
Nickel-metal hydride	1.2	60-120	150-200	600-1200	Yes
Nickel-cadmium	1.2	40-60	150-350	600-1200	Yes
Nickel-zinc	1.6	60-100	120-150	500-700	No
Li-ion	3.3	90-160	25-450	1200-2000	No
Lithium manganese oxide	3.9	150-200	420-500	1000-1500	No

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Sodium-nickel chloride	2.6	115-150	190-240	600-1000	No

Table.6.Types of Electrical Batteries

4. Control strategy:

In vehicle the complex power flow, energy economic, battery energy management, improving the efficiency of the system, extending the driving range is need to find the suitable optimizing technique.
According to the system requirement, various level of control techniques is introduced like Battery level control, converter level control, Motor control [28 -30]. To manage the overall system, supervisory control method is introduced. The high performance of the vehicle mainly depends on 1.) Sizing the powertrain configuration 2.) power flow control 3.) Driving pattern analysis. The sizing of the powertrain is including the selection motor, energy source, power converter and mechanical transmission system. After configured the components, using power flow control technique to manage the power between the motor, engine (HEV, PHEV), various power source like battery, ultra-capacitor, fuel cell. For this, various control strategy is analyzed. The control strategy is based on the mathematical modelling is classified into two type 1.) Rule based control 2.) Optimized control technique.

4.1. Rule based control techniques

Based on the human knowledge a set of criteria is designed for the Rule based control algorithm. The ultimate aim of this function is to achieve high performance of the vehicle with minimum cost. Based on the system configuration and output requirements, the set of the rule is created. Mathematical model was developed for this given powertrain configuration. From this data, state transition is developed and validated with past driving pattern of the vehicle. The result of the system shows some improve on vehicle performance and economical operation of the vehicle. But it cannot achieve the optimal behaviors of the vehicle.

To achieve the better response of the system, the rule is further calibrated based on real time the vehicle driving pattern.

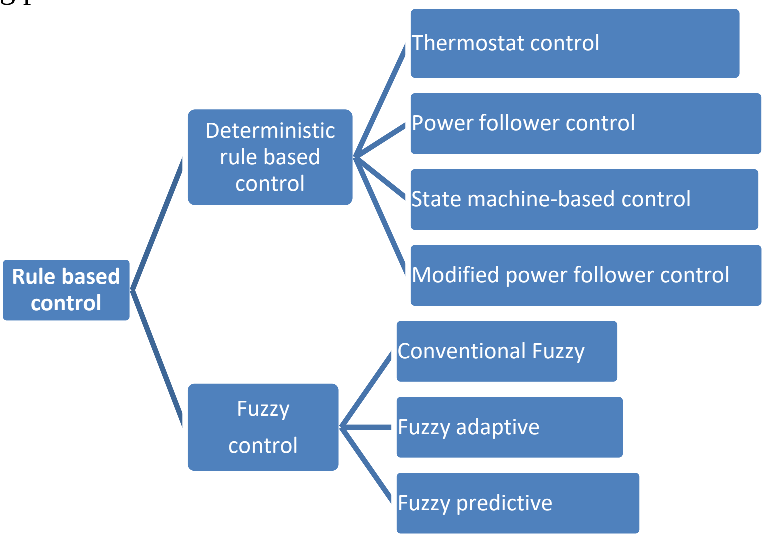

Figure.17. Classification of Control method

4.2. Optimized based control technique

This control algorithm based the on the different driving scenarios can control the fuel consumption and torque of the motor. These control techniques do not result in real-time

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energy management directly, but, based on an instantaneous cost function, a real-time control strategy can be obtained. The control algorithm is effective cost control method. This method of control mostly suitable for non-linear function. The rule-based system can't achieve the optimal behavior of the system. this is overcome by the optimized based control method. The recent the research are revealing that the rule-based control strategy result improvement is 32.9%. Using the optimized based control techniques, the result is improved to 57%.

5. Driving cycle:

The optimum of vehicle control is mainly based on the driving pattern of the electric vehicle. The supervisory of the control recognizing the different mode like idle, cursing mode of operation, start/stop, regenerative mode, high acceleration, deacceleration mode. The mode of operation of vehicle, required various range of control. The supervisory system, control power flow between load and source of the vehicle in standard level based on the standard driving pattern.

The driving cycle is kind of series data represent speed of vehicle versus time. The standard driving cycle are Europe NEDC: ECE R15/ EUDC,United States: FTP 72/75 / SFTP US06/SC03, Japan 10-15 Mode / JC08,Global Technical Regulations WLTP.The driving cycle data included acceleration, maximum speed, drive range.

6.Simulation:

The future transportation mainly depends on green energy and highly efficient system. From the various point of analysis, the technical demands are environmentally friendly, long range driving, optimum operation cost. According to the condition, the modern electric vehicle should mainly to satisfy the two objectives. First objective is flexible power train configuration of vehicle of electric vehicle. Comparing to the all the modern electric vehicle power train configuration, plug in hybrid electric vehicle having, both electric and mechanical propulsion system with onboard charging system. So, it is suitable in the point of long driving range, low pollutant. Fuzzy rule-based controller as shown in fig. 18.is used in the PHEV for satisfy the second objective of optimum energy management. The power demand of the vehicle for propulsion, will be controlled by the rule based fuzzy logic controller. Based on the torque requirement and SoC of the battery, the engine and electric drive system will be operated at the various load condition as shown in fig 19 and 20. This PHEV is simulated using Simulink in MATLAB with fuzzy login controller. This simulation results as shows the linear performance of the vehicle for FT 75 driving cycle.

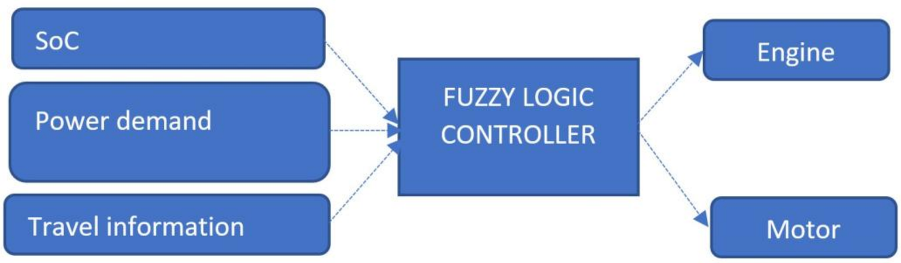

Figure.18. Fuzzy controller for PHEV

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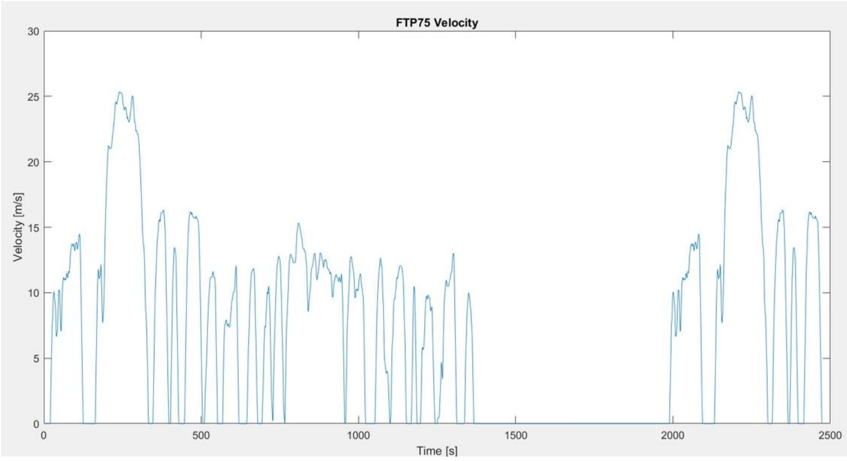

Figure.19. Driving cycle of USSD

Figure.20. Simulation result of Plug in hybrid electric vehicle

7.CONCLUSION

The field of transportation with help of modern technology has undergone many changes in day by day. This technology can improve performance of vehicle, energy management, low carbon emissions and also provide better solutions for long distance travel at low cost. It has made major changes to the systems of conventional vehicles. The electric motor can provide the required energy for vehicle propulsion. Also, the different type of motor like SRM, PMSM, BLDC, IM motor provide various range of power, torque and speed. The vehicle consists of a variety of converter, which suitable for manage the power between traction motor and a battery. It provides quality power for motor and accessories of vehicle system and reduces power loss. One of the things needed when an electric vehicle is running at high speeds is not only getting the power from the battery but also from other sources like Ultracapacitor, fuel cell, solar. The electric vehicle is divided into several types based on Primary and secondary source e.g., BEV, HEV, FCEV, REV. Each has several special functions, performance and special properties. The design and operation of PHEV is simulated using MATLAB.From the various analysis PHE, meet the most of requirements of customer and get their satisfaction.

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