ELECTRIC VEHICLE TECHNOLOGY

AN INTERNSHIP REPORT

Submitted in partial fulfilment of the requirements

for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

Submitted by

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BONAFIDE CERTIFICATE

Certified that this internship report **"ELECTRIC VEHICLE TECHNOLOGY"** is the bonafide work of **"*KOTHURTHI RAHUL* (PIN NO:20555A0321)"**, who carried out the project work under my supervision during the year 2022 to 2023, towards partial fulfilment of the requirements of the Degree of Bachelor of Technology in Mechanical Engineering as administered under the Regulations of Godavari Institute of Engineering & Technology (A), Rajamahendravaram, AP, India and award of the Degree from Jawaharlal Nehru Technological University, Kakinada. The results embodied in this report have not been submitted to any other University for the award of any degree.

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ABSTRACT

Electric vehicles (EVs) are a promising technology for achieving a sustainable transport sector in the future, due to their very low to zero carbon emissions, low noise, high efficiency, and flexibility in grid operation and integration. This chapter includes an overview of electric vehicle technologies as well as associated energy storage systems and charging mechanisms. Different types of electric-drive vehicles are presented. These include battery electric vehicles, plug-in hybrid electric vehicles, hybrid electric vehicles and fuel cell electric vehicles. The topologies for each category and the enabling technologies are discussed. Various power train configurations, new battery technologies, and different charger converter topologies are introduced. Electrifying transportation not only facilitates a clean energy transition, but also enables the diversification of transportation's sector fuel mix and addresses energy security concerns. In addition, this can be also seen as a viable solution, in order to alleviate issues associated with climate change. Furthermore, charging standards and mechanisms and relative impacts to the grid from charging vehicles are also presented.

CONTENTS

LIST OF ABBREVATIONS

2W: two-wheeler

3W: three-wheeler

4W: four-wheeler

AC: alternating current

BEE: Bureau of Energy Efficiency

BIS: Bureau of Indian Standards

CEA: Central Electricity Authority

CMS: Central Management System

CNA: Central Nodal Agency

CPO: charge point operator

C-rate: charge rate

DC: direct current

DDC: Dialogue and Development Commission of Delhi

DER: Distributed Energy Resources

DERMS: Distributed Energy Resources Management System

DHI: Department of Heavy Industry

DISCOMs: distribution companies

DT: distribution transformer

DTL: Delhi Transco Ltd

ECS: equivalent car space

EESL: Energy Efficiency Services Limited

e-MSPs: e-mobility service providers

EV: electric vehicle

EVCI: electric vehicle charging infrastructure

EVSE: electric vehicle supply equipment

FAME-II: Faster Adoption and Manufacturing of Electric Vehicles

FC: fast charger

GNCTD: Government of National Capital Territory of Delhi

HT: high tension

IEC: International Electrotechnical Commission

kV: kilovolt

kW: kilowatt

kWh: kilowatt hour

kWp: kilowatt peak

LCV: light commercial vehicle

LEV: light electric vehicle

MBBL: Model Building Byelaws

MCV: medium commercial vehicle

MoHUA: Ministry of Housing and Urban Affairs

MoP: Ministry of Power

MoRTH: Ministry of Road Transport and Highways

MoU: Memorandums of Understanding

OCPI: Open Charge Point Interface

OCPP: Open Charge Point Protocol

OEM: Original Equipment Manufacturer

OpenADR: Open Automated Demand Response

PCS: public charging station

PPAs: Power Purchase Agreements

PPP: public private partnership

PSU: Public Sector Undertaking

RTA: Regional Transport Authority

SC: slow charger

SERC: State Electrical Regulatory Commission

SLD: Service Line cum Development

SNA: State Nodal Agency

ToD: time-of-day

ToU: time-of-use

TWh: terawatt hours

UDA: urban development authority

ULB: urban local body

UMTA: Unified Metropolitan Transport Authority

UT: Union Territory

CHAPTER-1
INTRODUCTION

EVs within the scope of smart cities are gaining recognition as alternative ways through which a low-zero carbon society can be pursued. Discussion of the concept of electromobility and its interaction with the city and grid is made in order to point out the need for an integrated approach. In this context, the book tries to plot the plethora of possible pathways between what has already been achieved and what is still needed. This is achieved by exploring and assessing the ways through which EVs can be integrated into a city's transportation system and how this may create a complete set of new technologies and service offerings, offering at the same time a better quality of life.

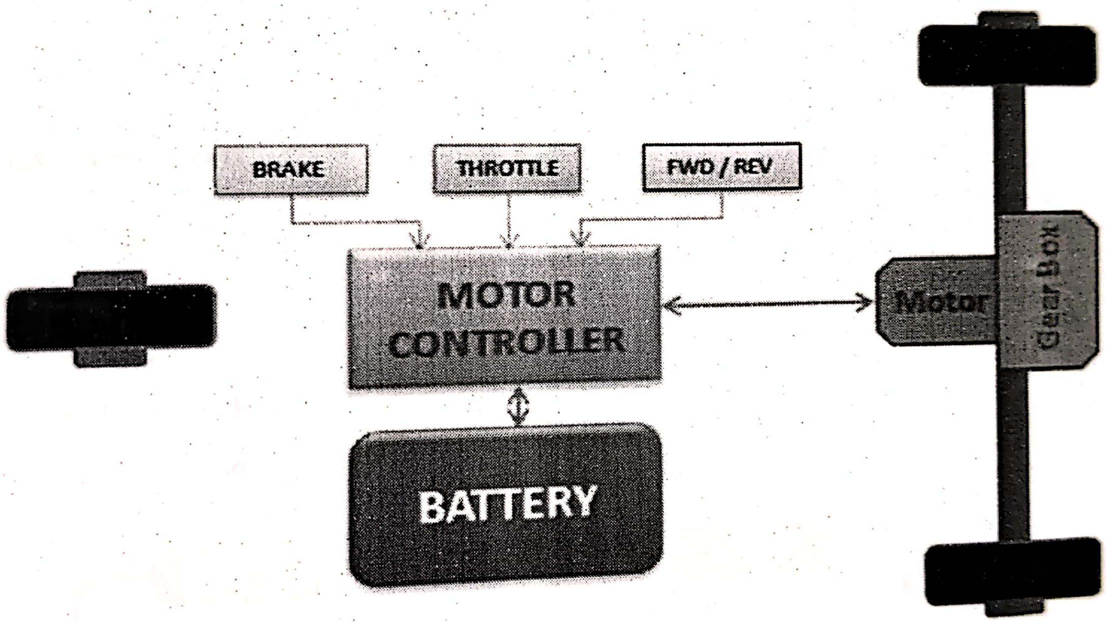
The goal of this book is to constitute a valuable tool that can be helpful to stakeholders and decision-makers in the process of regional and strategic planning, with reference to sustainable transport design. It aims to be helpful along the way in policy, practical, conceptual, and visionary ways. Thus, it aims to help in decision-making, with regard to the national and sustainable energy designs, and to demonstrate how EVs can best be utilized within cities. The book's objective is to provide useful insight to policy makers, urban planners, engineering consultancies, scientists, researchers, students, as well as citizens interested in supporting a smooth transition to the future energy landscape. Furthermore, the book aims to point out that the combination of external factors, such as stringent emissions regulations, rising fuel prices, financial incentives, intelligent load management, and exploitation of local renewables, can contribute to a decarbonized urban energy future.

Electric vehicle supply equipment (EVSE) is thebasic unit of EV charging infrastructure. The EVSEaccesses power from the local electricity supply andutilizes a control system and wired connection tosafely charge EVs. An EVSE control system enablesvarious functions such as user authentication,authorization for charging, information recording andexchange for network management, and data privacyand security. It is recommended to use EVSEs withat least basic control and management functions, forall charging purposes.Conductive charging, or plug-in (wired) charging, is themainstream charging technology in use. Requirementsof EVSE for conductive charging depend on factorssuch as vehicle type, battery capacity, chargingmethods, and power ratings.

1.1 DEFINITION OF ELECTRIC VECHILE

- The electric motorgets **energy from a controller**, which regulates the amount of power—based on the driver's use of an accelerator pedal. The electric car (also known as electric vehicle or EV) uses energy stored in its rechargeable batteries, which are recharged by common household electricity.
- All-electric vehicles (EVs), also referred to as battery electric vehicles, have an electric motor instead of an internal combustion engine. Because **itruns on electricity,** the vehicle emits no exhaust from a tailpipe and does not contain the typical liquid fuel components, such as a fuel pump, fuel line, or fuel tank.
- Electric transportation refers to**trains, trams, cars, buses and bikes which run on electricity.**

FIGURE 1.1 WORKING OF ELECTRIC VEHICLE



1.2 TYPES OF ELECTRIC VEHICLE

There are 4 (four) types of electric cars, with the following outline:

- **Battery Electric Vehicle (BEV)**
- **Hybrid Electric Vehicle (HEV)**
- **Plug-in Hybrid Electric Vehicle (PHEV)**
- **Fuel Cell Electric Vehicle (FCEV)**

1.3Battery Electric Vehicle (BEV)

1.3.1 WORKING PRINCIPLE

- Power is converted from the DC battery to AC for the electric motor
- The accelerator pedal sends a signal to the controller which adjusts the vehicle's speed by changing the frequency of the AC power from the inverter to the motor
- The motor connects and turns the wheels through a cog
- When the brakes are pressed or the electric car is decelerating, the motor becomes an alternator and produces power, which is sent back to the battery
- A Battery Electric Vehicle (BEV), also called All-Electric Vehicle (AEV),runentirely on a battery and electric drive train. types of electric cars do not have an ICE. Electricity is stored in a large battery pack at is charged by plugging into the electricity grid.

1.3.2 components

- Electric motor
- Inverter
- Battery
- Control Module
- Drive train

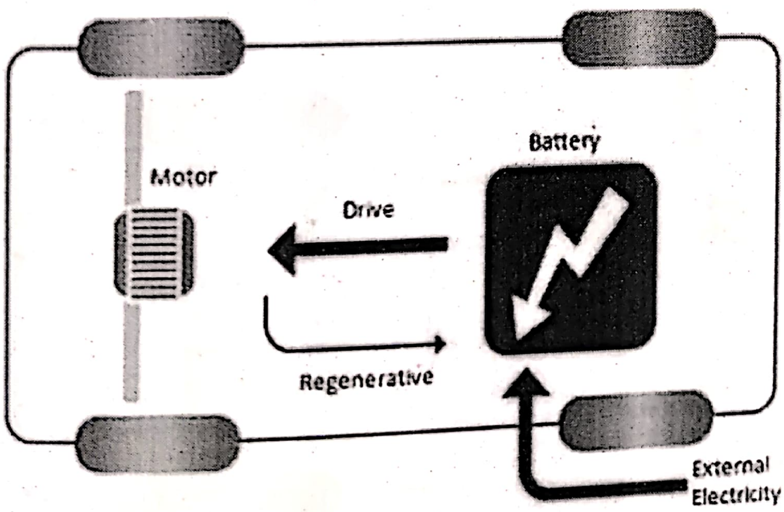


FIGURE 1.2 BATTERY ELECTRIC VECHILE

1.4 Hybrid Electric Vehicle (HEV)

1.4.1 WORKING PRINCIPLE

- This type of hybrid cars is often called as standard hybrid or parallel hybrid. HEV has both an ICE and an electric motor. In this types of electric cars, internal combustion engine gets energy from fuel (gasoline and others type of fuels), while the motor gets electricity from batteries. Whilethe motor gets electricity from batteries. The gasoline engine and electric motor simultaneously rotate the transmission, which drives the wheels.
- The difference between HEV compared to BEV and PHEV is where the batteries in HEV can only charge by the ICE, the motion of the wheels or a combination of both. There is no charging port, so that the battery cannot be recharged from outside of the system, for example from the electricity grid.

1.4.2 components

- Engine
- Electric motor
- Battery pack with controller & inverter
- Fuel tank
- Control module

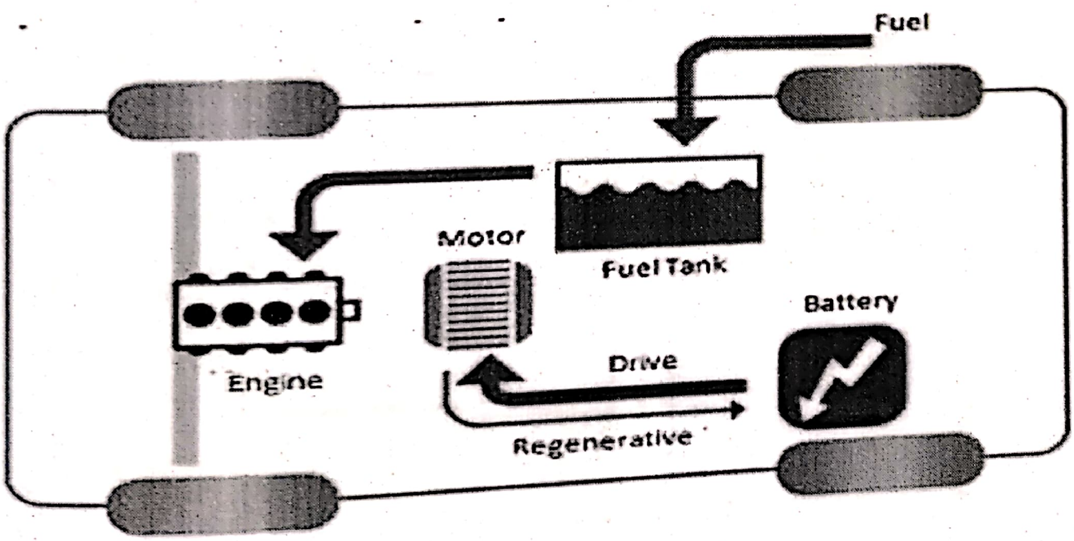


FIGURE 1.3 HYBRID ELECTRIC VECHILE

1.5 Plug-in Hybrid Electric Vehicle (PHEV)

1.5.1 WORKING PRINCIPLE

- PHEVs typically start up in all-electric mode and operate on electricity until their battery pack is depleted. Some models shift to hybrid mode when they reach highway cruising speed, generally above 60 or 70 miles per hour. Once the battery is empty, the engine takes over and the vehicle operates as a conventional, non-plug-in hybrid.
- In addition to plugging into an outside electric power source, PHEV batteries can be charged by an internal combustion engine or regenerative braking. During braking, the electric motor acts as a generator, using the energy to charge the battery. The electric motor supplements the engine's power; as a result, smaller engines can be used, increasing the car's fuel efficiency without compromising performance.

1.5.2 components

- Electric motor
- Engine
- Inverter
- Battery
- Fuel tank
- Control module
- Battery Charger (if onboard model)

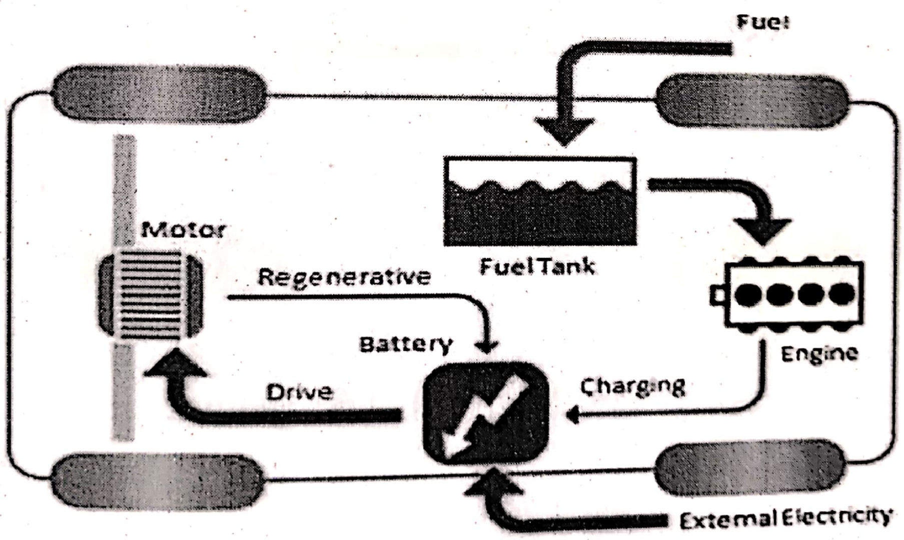


FIGURE 1.4 PLUG IN HYBRID ELECTRIC VECHILE

1.6 Fuel Cell Electric Vehicle (FCEV)

1.6.1 WORKING PRINCIPLE

- Fuel Cell Electric Vehicles (FCEVs), also known as fuel cell vehicles (FCVs) or Zero Emission Vehicle, are types of electric cars that employ 'fuel cell technology' to generate the electricity required to run the vehicle. In this type of vehicles, the chemical energy of the fuel is converted directly into electric energy.
- The working principle of a 'fuel cell' electric car is different compared to that of a 'plug-in' electric car. the types of electric cars is because the FCEV generates the electricity required to run this vehicle on the vehicle itself.

1.6.2 components

- Electric motor
- Fuel-cell stack
- Hydrogen storage tank
- Battery with converter and controller

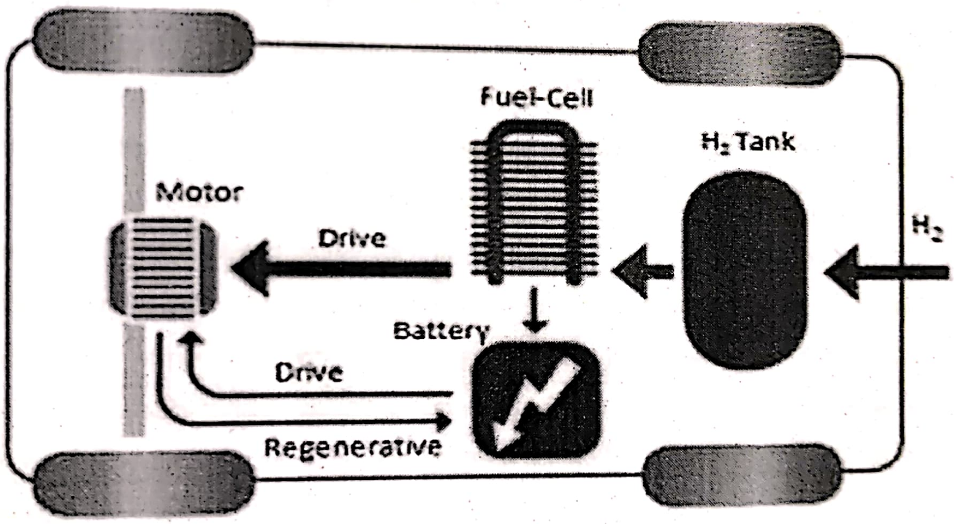


FIGURE 1.5 FUEL CELL ELECTRIC VECHILE

CHAPTER-2

COMPONENTS OF ELECTRIC VEHICLE

2.1 MOTOR

Electric motor is the electro-mechanical machine which converts the electrical energy into mechanical energy. In other words, the devices which produce rotational force is known as the motor. The working principle of the electric motor mainly depends on the interaction of magnetic and electric field.The electric motor is mainly classified into two types. They are the AC motor and the DC motor. The AC motor takes alternating current as an input, whereas the DC motor takes direct current.

2.2 types of motor used in electric vehicle

- A.C. induction motor
- Brushless motor
- Permanent Magnet Synchronous Motor
- APMDC Motor

2.3 A.C. INDUCTION MOTOR

An induction motor or asynchronous motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor.Three-phase squirrel-cage induction motors are widely used as industrial drives because they are self-starting, reliable and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFD) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump and compressor load applications. Squirrel-cage induction motors are very widely used in both fixed-speed and variable-frequency drive applications.

2.3.1 applications

Pumps.

Compressors.

Small fans.

High speed vacuum cleaners.

Electric shavers.

Drilling machines.

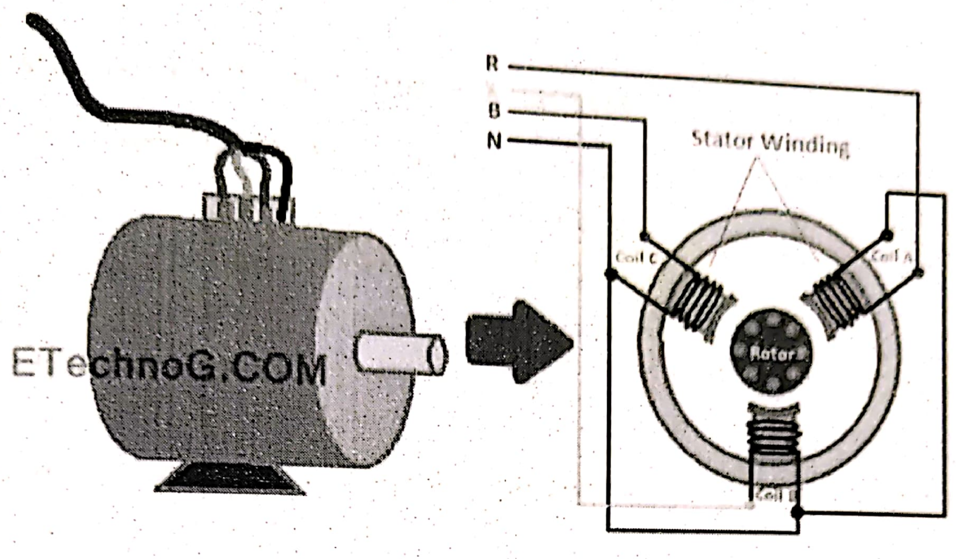


FIGURE 2.1 INDUCTION MOTOR

2.4 BRUSHLESS MOTOR

1. Primary efficiency is a most important feature for BLDC motors. Because the rotor is the sole bearer of the magnets and it doesn't require any power.
2. No connections, no commutator and no brushes. In place of these, the motor employs control circuitry. To detect where the rotor is at certain times, BLDC motors employ along with controllers, rotary encoders or a Hall sensor.
3. In this motor, the permanent magnets attach to the rotor.
4. The current-carrying conductors ararmaturewindingsare located on the stator.
5. They use electrical commutation to convert electrical energy into mechanical energy.
6. The main design difference between a brushed and brushless motors is the replacement of mechanical commutator with an electric switch circuit.A BLDC Motor is a type of synchronous motor in the sense that the magnetic field generated by the stator and the rotor revolve at the same frequency.

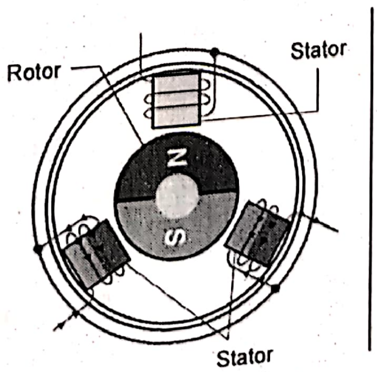


FIGURE 2.2 BRUSHLESS MOTOR

2.4.1 ADVANTAGES OF BRUSHLESS DC MOTOR

- Less overall maintenance due to absence of brushes.
- Reduced size with far superior thermal characteristics
- Higher speed range and lower electric noise generation.
- It has no mechanical commutator and associated problems
- High efficiency and high output power to size ratio due to the use of permanent magnet rotor
- High speed of operation even in loaded and unloaded conditions due to the absence of brushes that limits the speed
- Smaller motor geometry and lighter in weight than both brushed type DC and induction AC motors.
- Long life as no inspection and maintenance is required for commutator system
- Higher dynamic response due to low inertia and carrying windings in the stator
- Less electromagnetic interference
- Low noise due to absence of brushes

2.4.2 DISADVANTAGES

- These motors are costly
- Electronic controller required control this motor is expensive
- Requires complex drive circuitry
- Need of additional sensors

2.4.3 APPLICATIONS OF BRUSHLESS MOTOR

- Brushless DC motors (BLDC) use for a wide variety of application requirements such as varying loads, constant loads and positioning applications in the fields of industrial control, automotive, aviation, automation systems, health care equipment's etc.
- Computer hard drives and DVD/CD players
- Electric vehicles, hybrid vehicles, and electric bicycles
- Industrial robots, CNC machine tools, and simple belt driven systems
- Washing machines, compressors and dryers
- Fans, pumps and blowers.

2.5Permanent Magnet Synchronous Motor

- ThePermanent Magnet Synchronous Motor(PMSM) is an AC synchronous motor whose field excitation is provided by permanent magnets, and has a sinusoidal back EMF waveform. The PMSM is a cross between an induction motor and brushless DC motor. ... PMSM are typically used for high-performance and high-efficiency motor drives.
- •The working of PMSM depends onthe rotating magnetic field of the stator and the constant magnetic field of the rotor. The permanent magnets are used as the rotor to create constant magnetic flux, operates and locks at synchronous speed. These types of motors are similar to brushless DC motors.
- •Higher torque and better performance.More reliable and less noisy, than other asynchronous motors. High performance in both high and low speed of operation. Low rotor inertia makes it easy to control

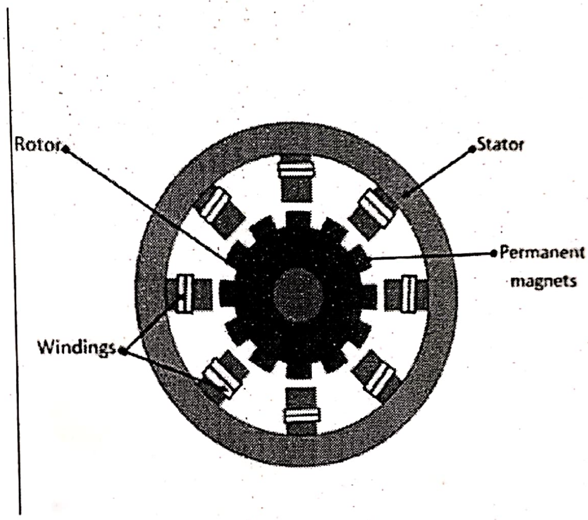


FIGURE 2.3 P.M.S.MOTOR

2.5.1Advantages

- Higher torque and better performance.More reliable and less noisy, than other asynchronous motors. High performance in both high and low speed of operation. Low rotor inertia makes it easy to control.
- Permanent Magnet Synchronous Motors have the potential to providing high torque-to-current ratio, high power-to-weight ratio, high efficiency and robustness. Due to the above favourable points, PMSMs are commonly used in latest variable speed AC drives, particularly in Electric Vehicle applications.

2.5.2Applications of(PMSM)

- Air conditioners.

- Refrigerators.
- AC compressors.
- Washing machines, which are direct-drive.
- Automotive electrical power steering.
- Machine tools.
- Large power systems to improve leading, and lagging power factor.
- Control of traction.

2.6 APMDC MOTOR

- No need of field excitation arrangement.
- No input power in consumed for excitation which improve efficiency of DC motor.
- No field coil hence space for field coil is saved which reduces the overall size of the motor.
- Cheaper and economical for fractional kW rated applications.

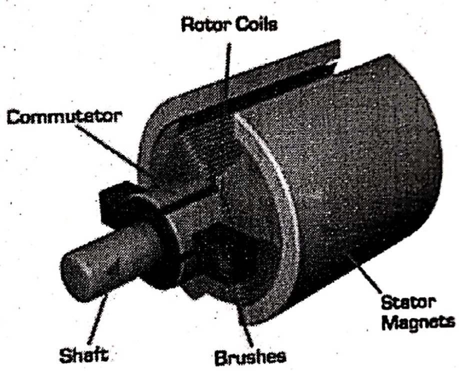


FIGURE 2.4 APMDC MOTOR

2.7 BATEERY

An **electric vehicle battery** (**EVB**, also known as a **traction battery**) is a rechargeable battery used to power the electric motors of a battery electric vehicle (BEV) or hybrid electric vehicle (HEV). Typically lithium-ion batteries, they are specifically designed for high electric charge (or energy) capacity. Electric vehicle batteries differ from starting, lighting, and ignition (SLI) batteries as they are designed to give power over sustained periods of time and are deep-cycle batteries. Batteries for electric vehicles are characterized by their relatively high power-to-weight ratio, specific energy and energy density; smaller, lighter batteries are desirable because they reduce the weight of the vehicle and therefore improve its performance. Compared to liquid fuels, most current battery technologies have much lower specific energy, and this often impacts the maximum all-electric range of the vehicles.

The most common battery type in modern electric vehicles are lithium-ion and lithium polymer, because of their high energy density compared to their weight. Other types of rechargeable batteries used in electric vehicles include lead–acid ("flooded", deep-cycle, and valve regulated lead acid), nickel-cadmium, nickel–metal hydride, and, less commonly, zinc–air, and sodium nickel chloride ("zebra") batteries.[1] The amount of electricity (i.e. electric charge) stored in batteries is measured in ampere hours or in coulombs, with the total energy often measured in kilowatt-hours (kWh). Since the late 1990s, advances in lithium-ion battery technology have been driven by demands from portable electronics, laptop computers, mobile phones, and power tools. The BEV and HEV marketplace has reaped the benefits of these advances both in performance and energy density. Unlike earlier battery chemistries, notably nickel-cadmium, lithium-ion batteries can be discharged and recharged daily and at any state of charge.

The battery pack makes up a significant cost of a BEV or a HEV. As of December 2019, the cost of electric vehicle batteries has fallen 87% since 2010 on a per kilowatt-hour basis.[2] As of 2018, vehicles with over 250 mi (400 km) of all-electric range, such as the Tesla Model S, have been commercialized and are now available in numerous vehicle segments. In terms of operating costs, the price of electricity to run a BEV is a small fraction of the cost of fuel for equivalent internal combustion engines, reflecting higher energy efficiency.

2.8 types of battery

- Lead acid
- Nickel metal hydride
- Zebra
- Lithium ion

2.9 lead acid battery

Flooded lead-acid batteries are the oldest, cheapest, and, in the past, most common vehicle batteries available. There are two main types of lead-acid batteries: automobile engine starter batteries, and deep cycle batteries. Automobile engine starter batteries are designed to use a small percentage of their capacity to provide high charge rates to start the engine, while deep cycle batteries are used to provide continuous electricity to run electric vehicles like forklifts or golf carts. Deep cycle batteries are also used as the auxiliary batteries in recreational vehicles, but they require different, multi-stage charging.[4] No lead acid battery should be discharged below 50% of its capacity, as it shortens the battery's life.[4] Flooded batteries require inspection of electrolyte levels and occasional replacement of water, which gases away during the normal charging cycle.

Previously, most electric vehicles used lead-acid batteries due to their mature technology, high availability, and low cost, with the notable exception of some early BEVs, such as the Detroit Electric which used a nickel–iron battery. Deep-cycle lead batteries are expensive and have a shorter life than the vehicle itself, typically needing replacement every 3 years.Lead-acid batteries in EV applications end up being a significant (25–50%) portion of the final vehicle mass. Like all batteries, they have significantly lower specific energy than petroleum fuels—in this case, 30–50 Wh/kg. While the difference isn't as extreme as it first appears due to the lighter drive-train in an EV, even the best batteries tend to lead to higher masses when applied to vehicles with a normal range. The efficiency (70–75%) and storage capacity of the current generation of common deep cycle lead acid batteries decreases with lower temperatures, and diverting power to run a heating coil reduces efficiency and range by up to 40%.

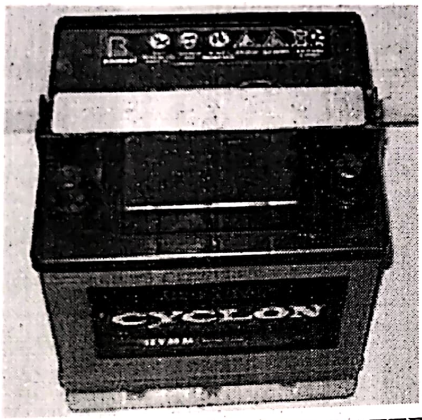


FIGURE 2.5 LEAD ACID BATTERY

2.10 Nickel metal hydride

Nickel-metal hydride batteries are now considered a relatively mature technology.[5] While less efficient (60–70%) in charging and discharging than even lead-acid, they have a specific energy of 30–80 Wh/kg, far higher than lead-acid. When used properly, nickel-metal hydride batteries can have exceptionally long lives, as has been demonstrated in their use in hybrid cars and in the surviving first-generation NiMH Toyota RAV4 EVs that still operate well after 100,000 miles (160,000 km) and over a decade of service. Downsides include the poor efficiency, high self-discharge, very finicky charge cycles, and poor performance in cold weather.

GM Ovonic produced the NiMH battery used in the second-generation EV-1, and Cobas's makes a nearly identical battery (ten 1.2 V 85 Ah NiMH cells in series in contrast with eleven cells for Ovonic battery). This worked very well in the EV-1.[6] Patent encumbrance has limited the use of these batteries in recent years.

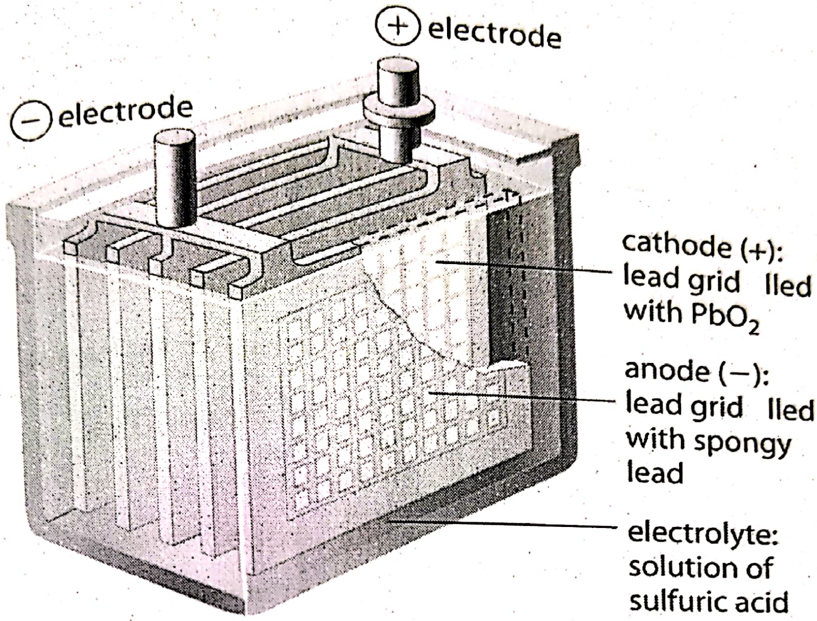
2.11 Zebra

The sodium nickel chloride or "Zebra" battery uses a molten sodium chloroaluminate ($NaAlCl_4$) salt as the electrolyte. A relatively mature technology, the Zebra battery has a specific energy of 120 Wh/kg. Since the battery must be heated for use, cold weather does not strongly affect its operation except for increasing heating costs. They have been used in several EVs such as the commercial vehicle.[7] Zebra batteries can last for a few thousand charge cycles and are nontoxic. The downsides to the Zebra battery include poor specific power (<300 W/kg) and the requirement of having to heat the electrolyte to about 270 °C (518 °F), which wastes some energy, presents difficulties in long-term storage of charge, and is potentially a hazard.

2.12 lithium-ion battery

lithium-ion (and the mechanistically similar lithium polymer) batteries, were initially developed and commercialized for use in laptops and consumer electronics. With their high energy density and long cycle life they have become the leading battery type for use in EVs. The first commercialized lithium-ion chemistry was a lithium cobalt oxide cathode and a graphite anode first demonstrated by N. Godshall in 1979, and by John Goodenough, and Akira Yoshino shortly thereafter.[8][9][10][11] The downside of traditional lithium-ion batteries include sensitivity to temperature, low temperature power performance, and performance degradation with age.[12] Due to the volatility of organic electrolytes, the presence of highly oxidized metal oxides, and the thermal instability of the anode SEI layer, traditional lithium-ion batteries pose a fire safety risk if punctured or charged improperly.[13] These early cells did not accept or supply charge when extremely cold, and so heaters can be necessary in some climates to warm them. The maturity of this technology is moderate. The Tesla Roadster (2008) and other cars produced by the company used a modified form of traditional lithium-ion "laptop battery" cells.

Recent EVs are using new variations on lithium-ion chemistry that sacrifice specific energy and specific power to provide fire resistance, environmental friendliness, rapid charging (as quickly as a few minutes), and longer lifespans. These variants (phosphates, titanates, spinels, etc.) have been shown to have a much longer lifetime, with A123 types using lithium iron phosphate lasting at least more than 10 years and more than 7000 charge/discharge cycles,[14] and LG Chem expecting their lithium-manganese spinel batteries to last up to 40 years.



FIGUER 2.6 LITHIUM ION BATTERY

2.13 BATTERY SAFETY

The safety issues of battery electric vehicles are largely dealt with by the international standard . This standard is divided into three parts:

- On-board electrical energy storage, i.e., the battery
- Functional safety means and protection against failures
- Protection of persons against electrical hazards.

Firefighters and rescue personnel receive special training to deal with the higher voltages and chemicals encountered in electric and hybrid electric vehicle accidents. While BEV accidents may present unusual problems, such as fires and fumes resulting from rapid battery discharge, many experts agree that BEV batteries are safe in commercially available vehicles and in rear-end collisions, and are safer than gasoline-propelled cars with rear gasoline tanks.

Usually, **battery performance testing** includes the determination of:

- State Of Charge (SOC)
- State of Health (SOH)
- Energy Efficiency

Performance testing simulates the drive cycles for the drive trains of Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV) and Plug in Hybrid Electric Vehicles (PHEV) as per the required specifications of car manufacturers (OEMs). During these drive cycles, controlled cooling of the battery can be performed, simulating the thermal conditions in the car.In addition, climatic chambers control environmental conditions during testing and allow simulation of the full automotive temperature range and climatic conditions.

2.14 ELECTRIC VEHICLE CHARGING METHODS

- Charge a New Electric Bike Battery for 12 Hours.
- Charge Your E-bike Battery Regularly.
- Avoid Temperature Extremes.
- Don't Overcharge an Electric Bike Battery.
- Don't Store an Empty Battery

2.15 THERMAL SYSTEM IN ELECTRIC VEHICLE

- This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
- The developed battery thermal management system is a **combination of thermoelectric cooling, forced air cooling, and liquid cooling**. Theliquid coolant has indirect contact with the battery and acts as themedium to remove the heat generated from the battery duringoperation.
- Thermal management systems in electric vehicles are generallymore **complex** than in conventional vehicles featuring combustionengines. The Axle, for example, must be cooled at all times while thebattery needs to be cooled or heated depending on the respectivesituation.
- To avoid possible damage through excessive torque, overcurrent or fierceaccelerations, the power on procedure must be adequately organised: it shall beimpossible to activate the controller with the accelerator depressed. Any unintentional movement of the vehicle during start-up shall be avoided.

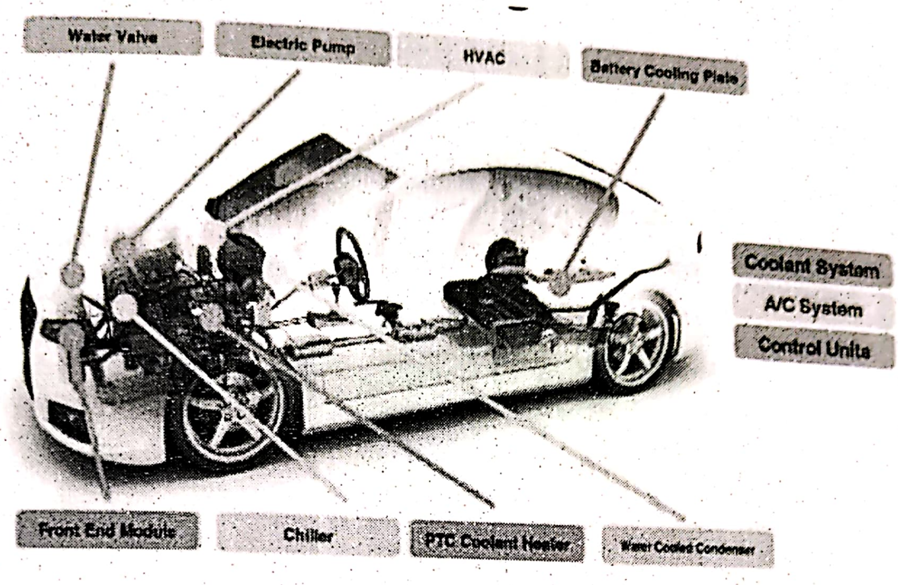


FIGURE 2.7 THERMAL SYSTEM

2.16 VEHICLE MAINTENANCE, OPERATION AND TRAINING

- EVs typically require **less maintenance than** conventional vehicles because:
- The battery, motor, and associated electronics require little to no regularmaintenance.
- There are fewer fluids, such as engine oil, that require regular maintenance.
- Brake wear is significantly reduced due to regenerative braking.
- Proper Training is very important before operating an Electric vehicle.
- Like bout E.V driving mechanisms, knowledge about operating interface.

CONCLUSION

The progress that the electric vehicle industry has seen in recent years is not only extremely welcomed, but highly necessary in light of the increasing global greenhouse gas levels. As demonstrated within the economic, social, and environmental analysis sections of this webpage, the benefits of electric vehicles far surpass the costs. The biggest obstacle to the widespread adoption of electric-powered transportation is cost related, as gasoline and the vehicles that run on it are readily available, convenient, and less costly. As is demonstrated in our timeline, we hope that over the course of the next decade technological advancements and policy changes will help ease the transition from traditional fuel-powered vehicles. Additionally, the realization and success of this industry relies heavily on the global population, and it is our hope that through mass marketing and environmental education programs people will feel incentivized and empowered to drive an electric-powered vehicle. Each person can make a difference, so go electric and help make a difference.

The future of electric vehicles, both in the short and the long term is very exciting. Firstly, there have been considerable developments in technology, which now allow advances in electric vehicle design to be made. Secondly, there are growing environmental concerns which are pressing society to find alternatives to IC engines alone as a source of power for vehicles. Environmental concerns encompass worries about carbon dioxide emissions and the effect of exhaust gas emissions on health. Thirdly, in the largest market for personal transport, the USA, there is an increasing realisation that fuel economy is important, for security reasons as well as environmental concerns. The Californian car market alone is about 1 000 000 units per year, and the rules of this state will continue to give a 'technology push' to developments in this area, as they have done so strongly up to now.