ISSN: 0974-5823 Vol. 7 No. 3 March, 2022

International Journal of Mechanical Engineering

A STUDY ON BATTERY MANAGEMENT SYSTEM AND CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLE DEVELOPMENT

Dr. Rajkumar Chougale [1], Dr. Devidas Mahadik [2],

[1] Principal,Adarsh Institute of Technology and Research Centre Vita ,(Maharashtra).

[2] Assistant Professor in Electrical Engg., Bharati Vidyapeeth College of Engg., Kolhapur (Maharashtra).

ABSTRACT

Batteries are the main source of electricity in electric cars. After a few kilometres of driving, the battery in electric vehicles needs recharging. As a result, the New Battery Management System has been proposed. An in-depth assessment of this innovative and fulfilling solution tobattery problems in electric cars is presented in this detailed review and investigation. Road and off-road vehicle manufacturers have developed a wide range of electric drives because ofstrict laws like CO2 limitations and the desire to have pollution-free transportation. In addition to numerous hybrid propulsion methods, battery and fuel cell electric ideas are also available. Diverse applications call for different system configurations, each with its own set of benefits and drawbacks. Therefore, battery technologies play a significant part in meeting the varied criteria of the vehicle designs exhibited. Both charging and discharging are taking place concurrently. As soon as one half is totally depleted, the other half is used and the other half isstored for charging. With this management, we do not need external charging and the car is self-charging, thus there will be no space issue because we are not utilising two separate batteries. These battery management systems are examined in depth in this research, so that their advantages may be assessed.

Keywords: Electric Road vehicles, Hybrid electric vehicles, Fuel cell, Battery, Management

INTRODUCTION

Primary and secondary batteries are the most common types of batteries. Non-rechargeable primary batteries can only be drained once and are not able to be recharged. "Dry cells" are another name for these sorts of batteries. A secondary battery can be recharged to its original state after being discharged. Rechargeable batteries are another name for this sort of battery. High energy density, high power density, extended cycle life for little maintenance, and cheap cost for greater market adoption are all necessary components of a rechargeable battery system in electric vehicles and plug-in hybrid electric vehicles (PHEVs). Secondary batteries meet most of the above-mentioned characteristics, hence they are commonly employed in electric vehicles. Over the course of the last century, secondary batteries have been developed. There are already a wide variety of secondary batteries on the market. These include lead-acid, nickel- cadmium, nickel-metal hydride (NiMH), and lithium-ion (Li-ion) batteries.

To reach specified driving lengths, electric vehicles need battery systems that can store enough energy and generate enough peak power to achieve a certain acceleration performance. Electrochemistry of secondary batteries, which are the building blocks of battery systems, is first introduced in order to better comprehend how EV batteries work. Afterwards, we go into the four types of secondary batteries' origins, working principles, performance, and uses. Using an electrochemical process, a battery cell converts chemical energy into electrical energy and vice versa an electrochemical battery cell schematically. In order to power an external load, thecell uses two collectors for positive and negative current: one on the negative electrode and oneon the positive electrode. The electrolyte can travel through the electrodes since they are bothsolid and porous.

However, electrons cannot flow through the separator, but positive and negative ions can go through the electrolyte. Electrons can flow via an external load thanks to the positive and negative current collectors. The positive and negative electrodes in the electrolyte solution have differing inclinations to acquire and lose electrons, which the cell takes advantage of. A drawback of electric cars in the current state of industrialisation, restricted product variety, and poor market sales is the high cost of electric vehicles. The battery systems, in particular, are one of the costliest parts of electric cars. Quality assurance has to be improved at existing production facilities. However, the purchase price of an electric car is not the only factor to consider when assessing the vehicle's economic viability. A company's total cost of ownership must also be considered. In terms of overall vehicle expenditures, lower maintenance costs and

decreased energy use are significant advantages. Electric cars also have the advantage of having no local emissions. For cities, this is a big advantage; pollution is reduced and an environmentally-friendly image is established. However, in order to fully use electric propulsion systems, the current energy mix must be modified to include more regenerative energy sources in order to establish a more sustainable system. Only if electric vehicle designs are monitored and optimised for CO2 emissions over the full product life cycle can they take use of their potentials. In addition to the more general advantages, electric road and off-road vehicles have significant advantages in their normal use when it comes to specific applications. In metropolitan areas, electric cars are being used in the delivery industry as one example. Fuelsavings can be substantial because the electric vehicle's full range isn't achieved when just localdeliveries are done.

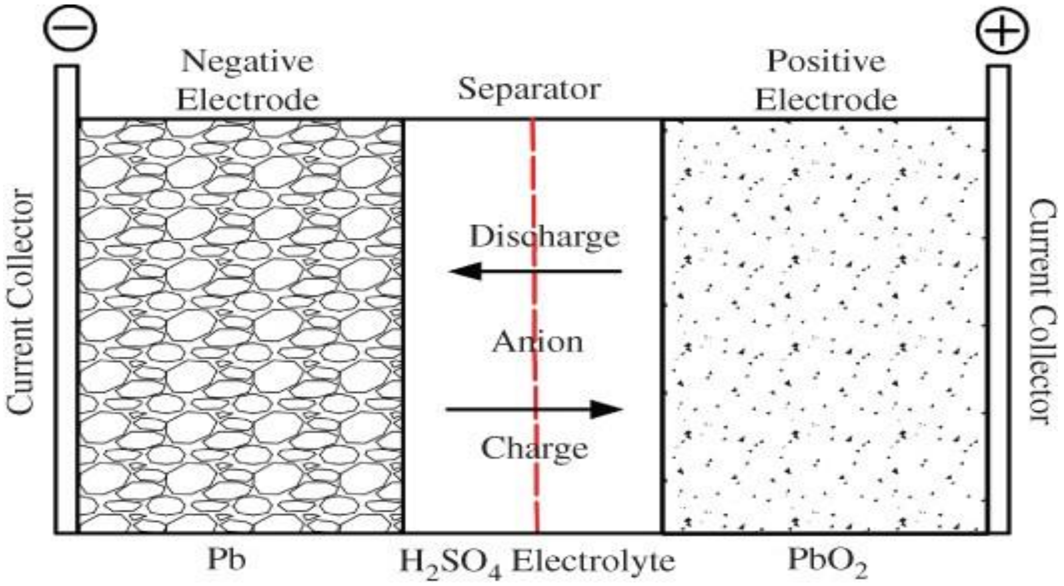

Figure 1 Battery Design

A 20 percent cost savings over the diesel equivalent is possible, depending on the situation. Another advantage is that the vehicle can accelerate quickly in urban traffic, resulting in decreased maintenance expenses. Cross-industry development in electric transportation might be considered. Electric propulsion systems for automobile and off-road use are still in a very early stage of industrialization, even though combustion engine technology is completely industrialised. When discussing the pros and drawbacks of electric cars, there are a number of other factors that must be taken into account. Energy consumption and supply must be rethought in this environment. It's critical to address the existing and future reliance on fossil fuels while discussing mobility. Hydrogen and electricity generated from renewable sources

are viable options for increasing the number of renewable fuels. The newest advancements in electric propulsion systems can also assist new research fields and activities in information technology and vehicle-to-vehicle connection. Together, they have the potential to develop innovative transportation options for cars that are currently on the road and operated in the same way. As it comes to electric cars, there are apparent advantages and disadvantages whencompared to traditional combustion engine-based vehicles. When it comes to system efficiency, the electric propulsion system's working principle offers several obvious advantages. An electric propulsion system has a far higher efficiency than a system powered by a combustion engine. An electric motor's efficiency may be as high as 95%, which is three times more than a combustion engine's efficiency. However, the electric propulsion system's greater weight, particularly in hybrids, is a major drawback.

Power electronics, hefty battery systems, and a heavy battery system combine to make a vehicleheavier than a vehicle with a combustion engine. However, the storage device's rechargeability compensates for the battery system's weight. Either the recuperation function or the grid charging option can be used to do this. The electric system has an advantage in terms of acceleration and power transmission as compared to the conventional method. Today's batteries have a poor energy density due to the complicated development of battery physics, which is a major drawback. Material, cell design, and processability have all seen advancements in the previous several years. Energy stored in batteries is used to power electric cars (EVs), which offer advantages over ICEVs in terms of the amount of energy they require, which may be supplied from numerous sources, including renewable energy sources (RESs). When batteries run low on power, grid electricity is used to refuel them.

In order for electric vehicles (EVs) to be genuinely clean and sustainable modes of transportation, more renewable energy sources (RESs) must be integrated into power grids. Voltage, frequency, and reactive power all suffer as a result of RES's intermittent nature. Energy storage is needed to compensate for a power system that generates too much electricityfrom Renewable Energy Sources (RESs) and sends it back into the grid to counter peak demand. It is possible to use the batteries in electric vehicles as energy storage and as power compensation, which improves power grid resilience and allows for greater acceptance of renewable energy sources (RESs). Electric vehicles' battery packs not only power the vehicle itself, but they also interchange energy with the grid to keep everything running smoothly.

LITERATURE REVIEW

C. -H. Chung (2020): Several studies have been conducted on battery management for plug-in electric cars (PEVs), most of which concentrate on PEV operating circumstances. Yet little is known about how electrochemical side reactions might degrade batteries when they're idle. Batteries degrade at different rates depending on their conditions, such as charge level and ambient temperature. PEV idling accounts for the vast majority of the time, which might havea significant influence on battery and vehicle life. A frequently available infrastructure, namely a charging unit, is used to evaluate battery maintenance during prolonged durations of idle. Thegoal of an optimised charging profile is to reduce battery deterioration while idle while yet meeting the charging energy requirements. Depending on the ambient temperature and the stateof the battery, optimal charging profiles may be derived.

A. Kawashima (2018): As reciprocal communication networks and electric power management infrastructure have advanced, an energy management system that automatically regulates supply-demand imbalances under user convenience and economic considerations is receiving more attention these days. New uses for electric and plug-in hybrid car batteries, on the other hand, are widely acknowledged as a critical component in building a sustainable society. We may also use the electric power stored in the vehicle's batteries for a variety of other things thanks to the advancement of vehicle-to-X technology an integrated charging control approach for in-vehicle batteries based on these backgrounds is presented in this study, which uses projected information on home power demand and future vehicle condition to optimise the charge/discharge of in-vehicle batteries. The semi-Markov model and dynamic programming are used to construct a prediction system for future vehicle states.

P. K. Dost (2018): There are new concerns and expectations that arise from the use of electric cars (EVs). Because of this, the charging procedure of electric vehicles is a fresh experience when driving one. The findings of a field test on user charging behaviour are detailed in this document. More than 500 persons with a high annual mileage participated in the field test, which involved incorporating the cars into their daily routines. The charging behaviour of 200persons is taken into consideration in this study. Battery electric cars

(BEVs) and long-range electric vehicles (EREVs) are contrasted in terms of user behaviour. Grid services based on electric vehicles are possible since most of the time, the vehicles are linked to a power source or parked close to one. In addition, the data demonstrate that BEVs and EREVs have differentuser behaviour.

METHODOLOGY

Batteries work in dynamic and deep cycle circumstances in many applications, increasing the risk of poor performance and early ageing of the battery. In order to increase EV performance and battery life, advanced battery management technologies (BMTs) are required. In order to fully understand BMTs, readers need be familiar with battery modelling, estimate of battery states, battery charging, battery balancing, and battery temperature management. The principles of electric vehicles are laid forth in this section. The performance of existing batterytechnologies and their energy and power needs in EVs are then addressed. Lastly, an overview of the most important battery management technologies (BMTs) and their roles will be provided. Conventional combustion engines are combined with electric motors in the plug-in hybrid vehicle (PHEV) powertrain concept. If the battery is large enough, electric propulsion can be used for a sufficient distance. As an added bonus, it may also be charged from the grid.

Plug-in hybrid cars often feature a more powerful electric traction motor than mild- or full- hybrid models. Between 30 and 80 kW can be selected. Battery capacity is also greater and canrange from 3 to 10 kWh on average. A strong electric motor propels the range-extended electricvehicle (REEV). The traction battery is charged by an auxiliary generator using a smaller combustion engine. The combustion engine is not connected to the driving axle since the designis a serial hybrid. This proposal also includes the ability to recharge the battery from the grid. With a battery size of 15 kWh, today's range-extended electric cars use strong electric motors (sometimes more than 100 kW). There is a large battery system and a strong electric motor in the battery electric vehicle (BEV).

There is no need for a combustion engine, gasoline tank, or exhaust system because the electricmotor propels the vehicle. Recuperation or the power grid might be used to power the vehicle. There is a broad range of vehicle designs for pure electric cars, which means that the technicalaspects of the electric motor or the battery capacity might vary greatly. If you're looking to getinto the luxury automotive market, you'll be looking at batteries with a capacity of 60kWh or more. For FCEVs, hydrogen is utilised as the energy source stored in a specific hydrogen tank,which is different from the electric drive systems that were previously mentioned. The electric motor is powered by the fuel cell system, which acts as an energy converter. In current fuel cell automobiles, the traction motor is typically between 30 and 100 kW. For the recuperation function, this propulsion idea employs a smaller battery (1–2 kWh). Propulsion systems comein a wide range of shapes and sizes, thus there is no one best fit. Vehicles of personal transportation, such as automobiles and two-wheelers, as well as public transportation vehicles,such as buses, are distinct from off-road vehicles, such as various types of mobile working machines. Different propulsion systems have to be evaluated for their appropriateness depending on the type of application. An alternate method for determining the compatibility of a propulsion system and its intended use. As a result, the driving and loading profiles have beenselected. Pure electric vehicles (PEVs) and plug-in hybrid electric vehicles (PHEVs) have beenidentified as one of the most effective strategies to reduce dependence on fossil fuels and greenhouse gas emissions and have attracted increasing attention from governments, industries, and customers as a result of this growing concern about sustainability and environmental issues. As part of the Paris climate agreement, several governments have taken significant stepstoward promoting electric vehicles. There is a worldwide rush to create and commercialise electric vehicles as a result of restrictions on the sale of diesel and gasoline-powered vehicles in certain nations. One of the important technologies in electric cars is power electronics.

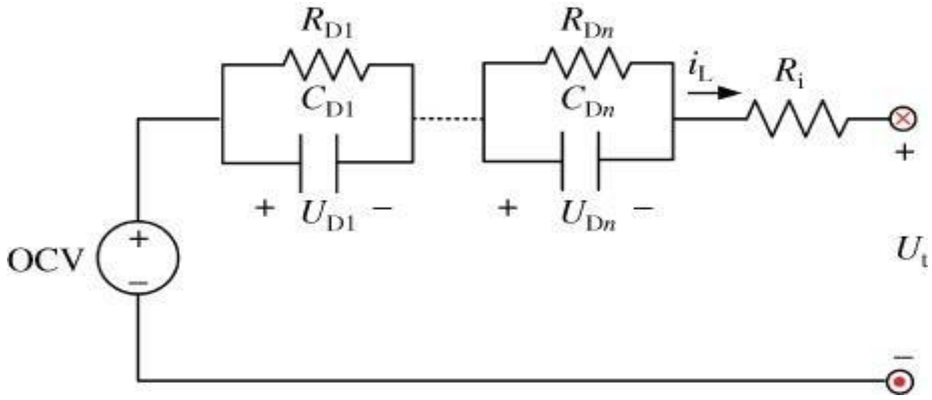

Figure 2 Battery Circuit Design

This includes the battery system and the traction motor. Hybrid and electric cars' total economyand efficiency depend heavily on the power electronics module in the vehicle's propulsion system. Electric machines require alternating power from a battery system, therefore direct current must be converted (or vice versa in the case of recuperation). As one of the most important responsibilities, this feature is essential. The power electronics module must also be able to step up or decrease the voltage in order to maintain the onboard supply of electricity. As a result, the charging process relies heavily on the power electronics. The equipment is usedto charge an electric vehicle from the grid. The charger must be able to convert the external current to the voltage required to charge the battery. From a technological standpoint, there are now two possibilities for charging devices. either the charger is built inside the car (known as an on-board charger) or it is attached to the charging column (known as an external charger) (called an off-board charger). On-board chargers (3.6–22 kW) are common in today's electric automobiles. It's more likely that the off-board option will be utilised for high-speed charging, which may take up to 50 kW of electricity. Discussions over charging process standardisation and the requisite components and connector systems have arisen since there are so many alternatives available. An example of a potential layout for the power electronics and how theyinteract with the energy storage system and the electric motor. Vehicle propulsion systems can be divided into traditional systems driven only by an internal combustion engine6 and electric propulsion systems7. Following, any electric propulsion ideas that are able to travel at least part of their journey using just electricity are categorised into this second class, regardless of whether they use a battery or fuel cell technology.

The spectrum of hybridization (micro-7, mild, full, or plug-in hybrid) or the architecture of the drivetrain differentiates the various electric propulsion systems. The configuration of the combustion engine, gearbox, electric motor (including power electronics), generator, or batteryis critical from an architectural point of view. The three types serial, parallel, and power-split hybrid can be distinguished based on the configuration. The many types of electric propulsion systems available on the market today. Parallel hybrids or power-split hybrids are the most common type of hybrids. For the combustion engine, the electric motor acts as a back-up. Botha parallel and a power-split hybrid drivetrain design are available. Using only electric power over a short distance is possible in many circumstances. The recovery function recharges the battery. Hybrid cars can be categorised as mild or complete hybrids based on how much assistance they receive from the electric motor.

When it comes to mild hybrids, the electric power ranges between 5 and 20 kW, but complete hybrids are currently equipped with an electric power range of more or less than 30 to 50 kW.Typical battery capacities range from 1 to 2 kWh. As these electrons go from one location to another, they will form a closed circuit with the resulting ions in the electrolyte solution, creating the current and supplying power and energy to the external load. The terms "anode" and "cathode" may be introduced easily. It's the electrode that absorbs electrons from the external circuit or the electrode where a reduction process takes place, which is known as a cathode. While the cathode is defined as the source of electrons for the external circuit, the anode is the source of oxidation. A battery cell's basic functioning concept is outlined below. Negative and positive electrodes are the cathode and anode, respectively, in the discharge process. Through the electrolyte and separator, positive ions go from the anode to the cathode.

EXPERIMENT RESULT

The opposite is true for negative ions. It is through the external load that electrons go from theanode (negative electrode) to the cathode (positive electrode). The anode and cathode generate a cell voltage Vt by accumulating negative and positive charges, respectively. A current is generated when this voltage is used to power an external load. When the electrons flow in the opposite way, it will be generated. Charge reverses the process. Anode and cathode are the two electrodes that make up a battery. Through the electrolyte and separator, the positive ions go from the anode to the cathode. The opposite is true for negative ions. By way of an external load, ions flow from the anode (positive electrode) to the cathode (negative). It is termed the reduction process when the negative electrode material dissolves in the electrolyte solution andgets an electron.

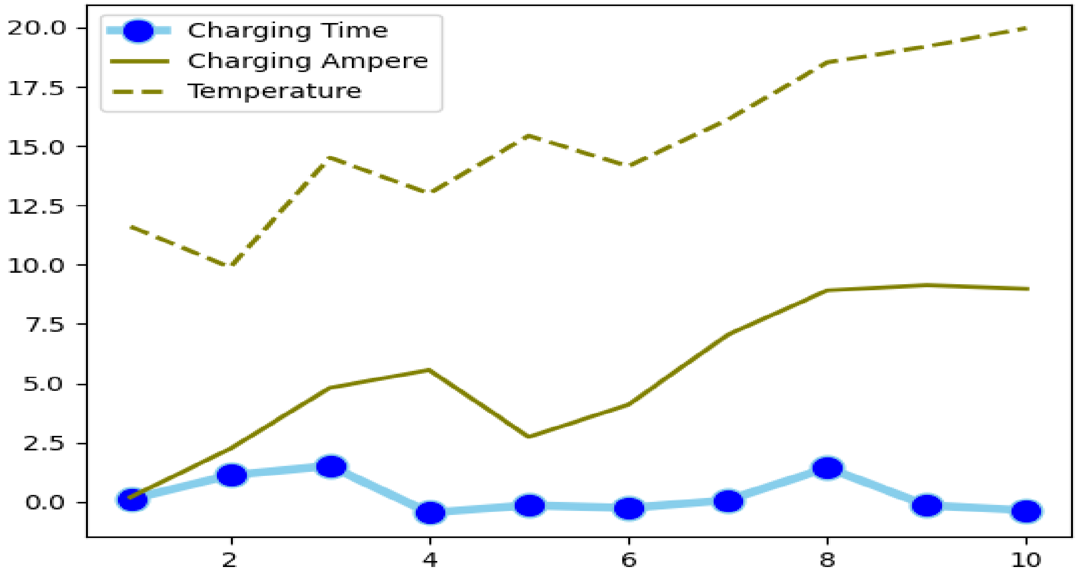

Figure 3 Battery Charging Management

An oxidation process occurs when the positive electrode loses an electron by depositing positive ions from the electrolyte. Secondary batteries have reversible oxidation–reduction processes. Thus, the electrodes can be restored to their pre-charged or pre-discharged states by charging or discharging the batteries. Under the influence of diffusion and migration, ions migrate through the electrolyte There must be an electrolyte concentration gradient for diffusion to occur. If no ions are produced, the electrolyte's ions will diffuse evenly throughout the cell over time. The electric field created by the positive and negative electrodes causes migration. To the negative electrode, the positive ions migrate, while the negative ions move

to the positive electrode. Energy may be stored and released by moving ions and electrons through an electrolyte and an external circuit. Electrified propulsion systems are built on a foundation of essential components. The battery system, the electric motor, the power electronics, and a proper charging mechanism are the most critical components. An energy storage device's overall performance and operating range are heavily influenced by the device'senergy storage capacity. Rechargeable batteries (e.g., lead-acid, nickel-metal hydride, orlithium-ion [Li-ion] batteries), capacitors, or the use of hydrogen as an energy source togetherwith the fuel cell operating as an energy converter are all types of energy storage devices that may be distinguished. The gravimetric energy density and power density (W/kg) of the variousbattery options varies. For example, hydrogen and gasoline have far higher energy density than secondary batteries. However, the superior efficiency of the electric powertrain as opposed to conventional combustion engines compensates for this disadvantage to some extent.

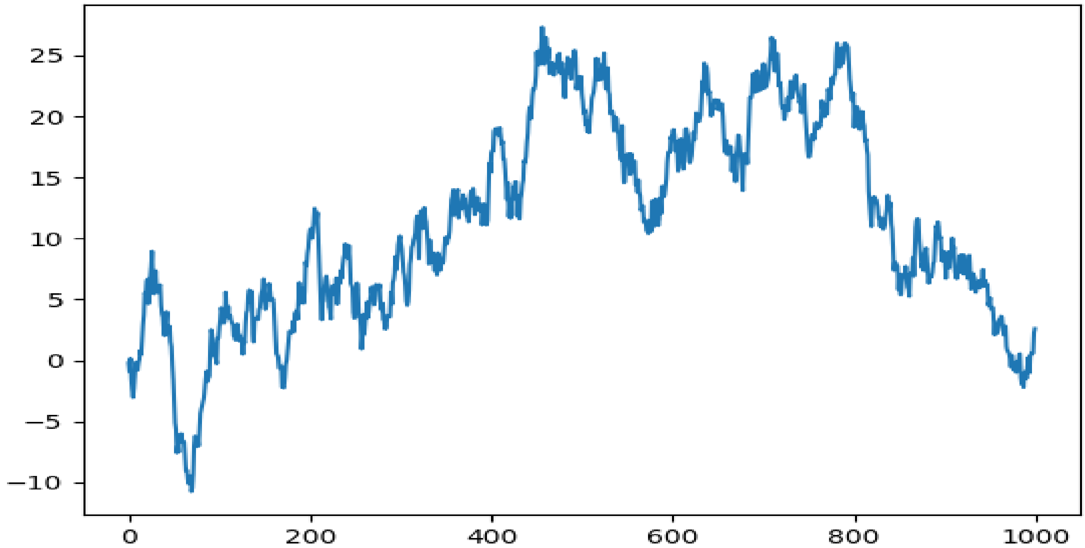

Figure 4 Battery Performance with Temperature

Under current technology, multiple battery packs must be installed in the vehicle to maintain agiven amount of range, but this increases the total weight of the vehicle. In addition to energydensity, additional considerations include power density, longevity and safety factors, useable capacity (discharge depth), and storage system prices. Many subsystems have been establishedinside the battery system in order to ensure performance (e.g., a battery management system ora suitable thermal management system). At this time, there isn't a single viable energy storage option. Electric motors have a wide range of advantages and disadvantages, which must be taken into account when designing a powertrain for an electric vehicle. The electric motor is

specified as the sole propulsion source in ideas such as the range-extender vehicle, the batteryelectric vehicle (BEV), or the fuel cell car. This makes the electric machine a fantastic alternative for the propulsion motor in automobiles since it has an amazing torque characteristic(maximum torque is accessible from zero revolutions per minute [rpm]). As an added benefit, electric machines are known for their great efficiency (up to 90%), durability and extended service lives, as well as cheap operating and maintenance expenses. Direct current machines and alternating current machines are two types of electric machinery. We'll examine the alternating current machine's operation because it's relevant to automotive applications. A three-phase alternating current powers this equipment. Using three 120-degree alternating voltages, the drive functions properly. A rotational magnetic field is created within the motor by feeding the stator windings. The rotor then follows. So-called inverters are essential components of power electronics because the battery's direct current must be converted to alternating current before it can be used in an electric machine. The following chapter providesan overview of electric road and off-road vehicles, taking into account the wide range of modelsavailable. Technical standards are the fundamental criterion for classifying vehicles in the European Union.

CONCLUSION

Because it is pollution-free and has a lower operating cost than other types of cars, we convert our regular automobiles to electric vehicles. We can increase the battery's efficiency by implementing a battery management system. We merge two batteries in the battery management system to create a new battery for the automobiles. There are a large range of electric propulsion systems that may be used in place of combustion engine-based systems. Many applications in the field of electric road and off-road vehicles can benefit from this type of propulsion system. Commercial trucks, off-road vehicles, and passenger cars can all benefit from these technologies. Electric concepts have many advantages, but they also have a number of drawbacks that aren't commonly understood. Many criteria and adaptability are needed for the battery system to play a vital role in the electric drivetrain. Here's a quick primer on the many types of electric drives available for various tasks. The electric vehicle's performance may be greatly improved by using a sophisticated battery management system. To ensure the safety and efficiency of electric cars, the battery management system is an essential component. In addition, they offer answers to electric vehicle difficulties like as inclination, power, and heating.

REFERENCE

1. C. -H. Chung, S. Jangra, Q. Lai and X. Lin, "Optimization of Electric Vehicle Charging for Battery Maintenance and Degradation Management," in IEEE Transactions on Transportation Electrification, vol. 6, no. 3, pp. 958-969, Sept. 2020, doi: 10.1109/TTE.2020.3000181.
2. A. Kawashima, T. Suzuki, S. Inagaki, T. Yamaguchi and Z. Zhou, "Model Predictive Charging Control of In-Vehicle Batteries for Home Energy Management Based on Vehicle State Prediction," in IEEE Transactions on Control Systems Technology, vol. 26, no. 1, pp. 51-64, Jan. 2018, doi: 10.1109/TCST.2017.2664727.
3. P. K. Dost, P. Spichartz and C. Sourkounis, "Charging Behavior of Users Utilizing Battery Electric Vehicles and Extended Range Electric Vehicles Within the Scope of aField Test," in IEEE Transactions on Industry Applications, vol. 54, no. 1, pp. 580-590,Jan.-Feb. 2018, doi: 10.1109/TIA.2017.2758753.
4. X. Feng, M. Ouyang, X. Liu, L. Lu, Y. Xia and X. He, "Thermal runaway mechanism of lithium ion battery for electric vehicles: A review", Energy Storage Mater., vol. 10,pp. 246-267, Jan. 2018.
5. G. L. Plett, "Extended Kalman filtering for battery management systems of LiPB-based HEV battery packs", J. Power Sources, vol. 134, no. 2, pp. 277-292, Aug. 2004.
6. X. Lin, Y. Kim, S. Mohan, J. B. Siegel and A. G. Stefanopoulou, "Modeling and estimation for advanced battery management", Proc. Annu. Rev. Control Robot., pp. 393-426, 2019.
7. Z. Chen, R. Xiong, J. Tian, X. Shang and J. Lu, "Model-based fault diagnosis approachon external short circuit of lithium-ion battery used in electric vehicles", Appl. Energy,vol. 184, pp. 365-374, Dec. 2016.
8. C. R. Birkl, M. R. Roberts, E. McTurk, P. G. Bruce and D. A. Howey, "Degradation diagnostics for lithium ion cells", J. Power Sources, vol. 341, pp. 373-386, Feb. 2017.
9. S. J. Moura, J. L. Stein and H. K. Fathy, "Battery-health conscious power managementin plug-in hybrid electric vehicles via electrochemical modeling and stochastic control",IEEE Trans. Control Syst. Technol., vol. 21, no. 3, pp. 679-694, May 2013.
10. S. Zhang, X. Hu, S. Xie, Z. Song, L. Hu and C. Hou, "Adaptively coordinated optimization of battery aging and energy management in plug-in hybrid electric buses",Appl. Energy, vol. 256, Dec. 2019.
11. X. Li, F. He and L. Ma, "Thermal management of cylindrical batteries investigated using wind tunnel testing and computational fluid dynamics simulation", J. Power Sources, vol. 238, pp. 395-402, 2013.
12. Z. Song, H. Hofmann, J. Li, J. Hou, X. Zhang and M. Ouyang, "The optimization of a hybrid energy storage system at subzero temperatures: Energy management strategy design and battery heating requirement analysis", Appl. Energy, vol. 159, pp. 576-588,Dec. 2015.
13. B. Suthar, V. Ramadesigan, S. De, R. D. Braatz and V. R. Subramanian, "Optimal charging profiles for mechanically constrained lithium-ion batteries", Phys. Chem. Chem. Phys., vol. 16, no. 1, pp. 277-287, 2014.
14. H. E. Perez, X. Hu, S. Dey and S. J. Moura, "Optimal charging of li-ion batteries withcoupled electro-thermal-aging dynamics", IEEE Trans. Veh. Technol., vol. 66, no. 9, pp. 7761-7770, Sep. 2017.
15. D. F. Frost and D. A. Howey, "Completely decentralized active balancing battery management system", IEEE Trans. Power Electron., vol. 33, no. 1, pp. 729-738, Jan. 2018.