International Journal of Scientific Research in Multidisciplinary Studies
Vol.8, Issue.2, pp.53-58, February (2022)
Review Paper
E-ISSN: 2454-9312
P-ISSN: 2454-6143

Review On Battery Management System In Eleectric Vehicles

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Available online at: www.isroset.org

Received: 03/Dec/2021, Accepted: 21/Jan/2022, Online: 28/Feb/2022

Abstract**—** Most elegant response to the ongoing environmental issues as well as an increasing demand of more efficient, sustainable, and less polluting vehicles, has been inevitable during these recent years. Also Limited supply of fossil fuels and their destructive impacts on the environment has led us to search for an alternative transportation propulsion system, which emits less pollutants and consumes less fossil fuel as well. The most popular solution appears to be an electric hybrid vehicle with a great and efficient battery management. Battery management systems (BMS) is often used in electric vehicle to monitor and control the charging and discharging of rechargeable batteries which makes the operation more economical. Battery management system keeps the battery safe, reliable and increases the senility without entering damaging state. (BMS) while they are providing necessary power. The battery installed in an electric vehicle should not only provide long lasting energy but also provide high power sufficient to make it viable. Lead-acid, Lithium-ion, -metal hydride are the most used traction batteries of all these traction batteries lithium-ion is most used because of its advantages and its performance. To maintain the state of the battery, voltage, current, ambient temperature different monitoring techniques are used. For monitoring purpose already obtained data from different analogue/digital sensors with microcontrollers are used. This ongoing project identifies and deals with various factors like state of charge, state of health, and state of life and maximum capacity of a battery. By analysing all these various future challenges and possible solutions that can be obtained.

Keywords— Electric vehicles, Battery Management System, State of charge estimation, State of Health Estimation

I. INTRODUCTION

Electric vehicles (EV) are playing a key role because of its zero-emission of harmful gases and use of efficient energy. Electric vehicles are equipped by many battery cells which require an effective battery management system (BMS). Battery Management system is any electronic system that manages a rechargeable battery, such as by protecting the battery, operating safely, monitoring states, calculating secondary data, reporting the data.

Battery management system (BMS) makes decisions based on

- ✓ Battery charging and discharging rates
- ✓ State of charge estimation
- ✓ State of health estimation
- ✓ Voltage
- ✓ Current
- ✓ Temperature etc.

Most Popular Types of Battery in EV's

- ✓ Li-ion Battery
- ✓ Lead acid Battery
- ✓ NiCad Battery
- ✓ NiMH Battery.

II. RELATED WORK

A brief review on key technologies in the battery management system of electric vehicles has been done by K Liu et. al [1]. This paper mainly gives us a brief review on several key technologies of battery management system, such as battery modelling, state estimation, battery charging. Also, other popular battery types used in Electric vehicles are surveyed. Battery Management System in Electric Vehicles [2] keeps the battery safe and increases the senility without entering damaging state. In order to do that the state of the battery, voltage, current, ambient temperature different monitoring techniques are used and those methodologies are reviewed here.

Bedatri Moulik et. al., [3] have done an optimal design of the cell structure, the runtime performance of the battery needs to be continuously monitored and optimized for a safe and reliable operation and prolonged life. Improved charging techniques need to be developed to protect and preserve the battery, so innovative design concepts are explored.

Fundamentals and applications of lithium-ion batteries in electric drive vehicles have been described by J Jiang and C Zhang [4]. The performance and capacity of batteries degrade due to the disordering and deforming of electrode structure, decomposition of the electrolyte, dissolution of metal, dendrite formation, The relative importance of these mechanisms in battery-chemistry are discussed. Electric Hybrid vehicle profits [5] from electrical machines and electrical storages, the other hybrid vehicles can include a compressed air energy here, the pros and cons of electric hybrid vehicles has been discussed. Battery management system keeps the battery safe and increases the senility without entering into damaging state [6]. In order to do that the state of the battery, voltage, current, ambient temperature different monitoring techniques are used and those methodologies are reviewed here. Supercapacitors [7] are widely used nowadays. These High-pressure, high-efficiency energy storage devices are also known as Ultracapacitors or electrochemical double-layer capacitors (EDLC) their applications are discussed in this paper in a detailed manner.

Every electric propulsion system is based on key components that make the concept work [8]. The most important components are the energy storage device, battery system, electric machine, the power electronics, and a suitable charging device. Existing technological fundamentals and potential development paths are explored. In the article analysis of battery management system issues in electric vehicles [9], it explains about the different batteries and their electrochemical implications, whose parameters are to be estimated well for their good maintenance. The measurable variables such as voltage, current, temperature that varies with state of charge are effectively measured. This book [10] provides insights about the investments in advanced battery technology, the adoption of these batteries in EVs on the road, and estimates the economic benefits associated with these improved technologies. It provides a detailed global evaluation of the net benefits associated.

A. Objective of the work

The major objective is to tackle the limited supply of fossil fuels and their destructive impacts on the environment has led us to search for an alternative transportation propulsion system, which emits less pollutants and consumes less fossil fuel as well. The most popular solution appears to be an electric hybrid vehicle with a great and efficient battery management. Battery management systems (BMS) is often used in electric vehicle to monitor and control the charging and discharging of rechargeable batteries which makes the operation more economical. Battery management system keeps the battery safe, reliable and increases the senility without entering damaging state. (BMS) while they are providing necessary power. The battery installed in an electric vehicle should not only provide long lasting energy but also provide high power sufficient to make it viable [11]. Lead-acid, Lithium-ion, -metal hydride are the most used traction batteries of all these traction batteries lithium-ion is most used because of its advantages and its performance. To maintain the state of the battery, voltage, current, ambient temperature different monitoring techniques are used. For monitoring purpose already obtained data from different analogue/digital sensors with microcontrollers are used. This ongoing project identifies and deals with various factors like state of charge, state of health, and state of life and maximum capacity of a battery. By analysing all these various future challenges and possible solutions that can be obtained.

III. KEY TECHNOLOGIES IN BATTERIES

On the other hand, battery needs particular care in the EV applications. Incorrect operations such as too high or too low temperature, over charging or discharging will speed up the degradation process of battery dramatically. Besides, battery pack in EVs is generally composed of hundreds of battery cells connected in series or parallel configuration to satisfy the high power and high voltage requirement for the vehicles. Care also needs to be taken to operate such a complicated battery pack. Therefore, a proper BMS is crucial in protecting batteries from damages, which needs be carefully designed.

In the applications of EVs, battery current and voltage can be detected by on-board current sensor and voltage sensor directly, and surface temperature of battery pack can be also detected by temperature sensor or thermocouple conveniently. Then the well-trained battery models together with suitable estimation methods can be adopted to achieve independent or joint state estimations of battery SOC or internal temperature. After capturing battery electric and thermal behaviours, battery charging approaches can be optimized by proper optimization algorithms.

Further to charge battery from initial state to final target with the equilibration of various charging objectives such as fast charging, high efficiency of energy conversion and low temperature rise [12]. If any abnormal situations of battery states occur in the operation process, the alarm module and safety control module will work to record or eliminate these cases accordingly. Therefore, battery modelling, state estimation and battery control are vital technologies in the BMS and these technologies become the thriving areas of research in the applications of BMS/EVs.)

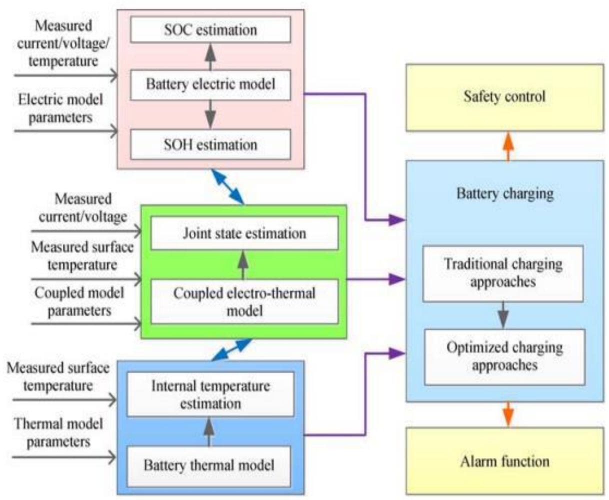

Figure 1. Function Of Battery Management System

A. Function of BMS

The BMS electric vehicle battery management system is an important link between the onboard power battery and the electric vehicle. BMS collects, processes, and stores important information during the operation of the battery pack in real-time, exchanges information with external devices such as vehicle controllers, and solves key issues such as safety, availability, ease of use, and service life in the lithium battery system. The main function is to improve the utilization rate of the battery, prevent the battery from being overcharged and over-discharged, and prolong the service life of the battery. Monitor the status of the battery [13]. In layman's terms, it is a system for managing, controlling, and using battery packs. The three core functions of BMS are explained as follows.

B. Battery Cell Monitoring

Accurate temperature measurement is also very important for the working status of the battery pack, including the temperature measurement of a single battery and the temperature monitoring of the heat dissipation liquid of the battery pack. This requires a reasonable set of the location and number of temperature sensors.

C. State of charge Estimation

Single-cell SOC calculation is the key and difficult point in BMS. SOC is the most important parameter in BMS because everything else is based on SOC. Basic, so its accuracy and robustness (also called error correction capability) are extremely important. If there is no accurate SOC

D. Cell Balancing

Passive balancing generally uses resistance heat to release the "excess power" of high-capacity batteries, so as to achieve the purpose of balancing. The circuit is simple and reliable, and the cost is low, but the battery efficiency is also low. During active equalization charging, the excess power is transferred to high-capacity cells, and the excess power is transferred to low-capacity cells during discharging.

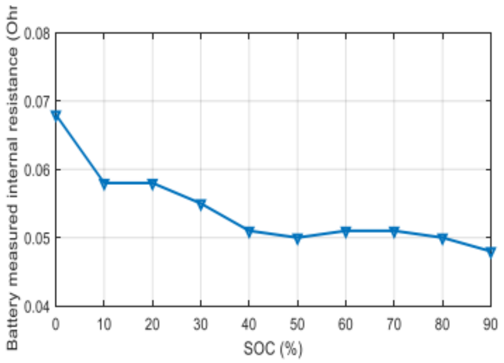

Figure 2. SoC Vs Internal resistance

IV. STATE OF HEALTH ESTIMATION

To cope with the new transportation challenges and to ensure the safety and durability of electric vehicles and hybrid electric vehicles, high performance and reliable battery health management systems are required. The Battery State of Health (SOH) provides critical information about its performances, its lifetime and allows a better energy management in hybrid systems [14]. Several research studies have provided different methods that estimate the battery SOH. Yet, not all these methods meet the requirement of automotive real-time applications. The real time estimation of battery SOH is important regarding battery fault diagnosis. Moreover, being able to estimate the SOH in real time ensure an accurate State of Charge and State of Power estimation for the battery, which are critical states in hybrid applications.

The SOH, as mentioned previously, is a figure of merit that indicates the level of degradation of the battery. Its calculation, however, cannot be conducted through direct measurements. It needs to be estimated using SOH indicators that are the battery capacity, its resistance or its impedance (some research lists the battery impedance and internal resistance as the same indicator, yet since the methods used to estimate them are different this work has listed them separately) [15]. Due to their real time feasibility, a huge interest, in automotive research, has been given lately to model-based methods for estimating these indicators and evaluating the battery SOH. These methods use models that describe the battery behaviour considering SOH indicators.

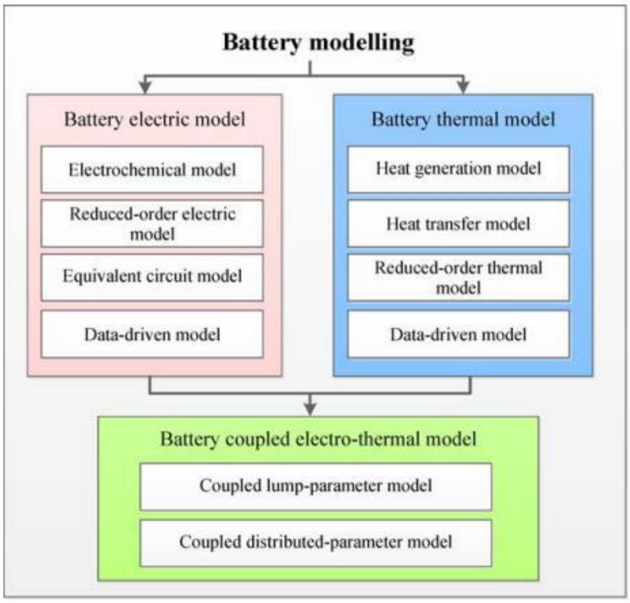

Figure 3. Battery Modelling

In order to estimate the battery states and their performances, these indicators are identified. Battery internal resistance is an indicator of great interest in terms of hybrid applications. This indicator reflects the battery degradation related to its power capability.

Building a proper model is usually the starting point for BMS design, control, and optimization [16]. Over the years, numerous battery models with various levels of accuracy and complexity have been developed. These models can be primarily categorized as the battery electric model, battery thermal model, and battery coupled model, which are detailed other model types such as battery kinetic models that are far less used in BMS are not covered in this paper.

A. Battery Electric Model

Battery electric models mainly include electrochemical model, reduced-order model, equivalent circuit model and data-driven model. Electrochemical model presented a highly accurate prediction performance but required significant computation effort in model simulation. Then a model implementation scheme was developed to embed electrochemical model into the BMS. The main advantage of using electrochemical model is that a highly accurate description of electrochemical processes within the battery can be obtained.

Besides, these electrochemical models usually involve many partial differential equations which need to be solved, resulting in large computational overheads [17]. By making suitable assumptions, the full-order electrochemical models can be approximated by reduced-order model. Although this approach leads to some information loss in the simplified reduced-order models, they are more desirable for real-time applications of batteries. The computational overheads become much lower for reduced-order models, and the corresponding parameters can be identified by the measured current and voltage signals. For equivalent circuit models, battery electric behaviours have been captured by a combination of circuit components

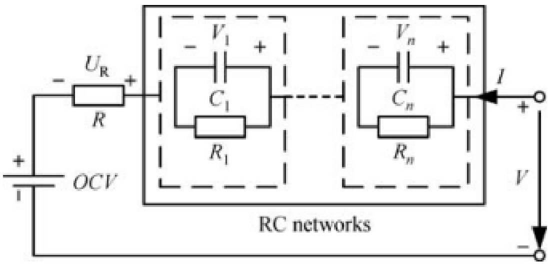

Figure 4. Equivalent circuit model

B. Battery Thermal Model

Thermal behaviour such as temperature is also a key aspect in the BMS of EVs because temperature plays a vital role in battery performance and lifetime. Various models such as heat generation model, heat transfer model, reduced-order thermal model and data-driven model have been developed to capture the thermal behaviours of batteries. For the heat generation model, several methods are introduced to describe the heat generation in battery, such as activation, concentration and ohmic losses, which distribute non-uniform inside the battery [18].

After defining battery heat generation and transfer parts, many batteries reduced-order thermal models have been also developed to achieve control purpose for battery thermal management, the order of a Li-ion battery model is reduced by converting the one-dimensional boundary-value problem into a low-order linear model in the frequency domain. The temperature prediction of the reduced order model matches closely with the experimental data and a three-dimensional finite-element simulation.

The three-dimensional heat transfer models can capture temperature distribution inside the battery, which can be applied to detect possible hot spots, especially in high-heat generation applications. However, the computational overheads of these heat transfer models are often too large for real-time applications, and they are mainly used in offline simulations.

C. Battery coupled Electro-thermal model

There is strong coupling between the battery electric and thermal behaviours. To capture battery electric behaviours (e.g., current, voltage, SOC) and thermal behaviours (e.g., surface and internal temperature) simultaneously, several coupled electro-thermal models have been developed in the literature, including both lump parameter and distributed-parameter models. Further, Goutam et al. proposed a three-dimensional electro-thermal model to estimate battery SOC and calculate heat generation [19]. This coupled model consists of a 2D potential distribution model and a 3D temperature distribution model. Then the battery SOC and temperature distribution under both constant and dynamic currents are effectively calculated based on this coupled model.

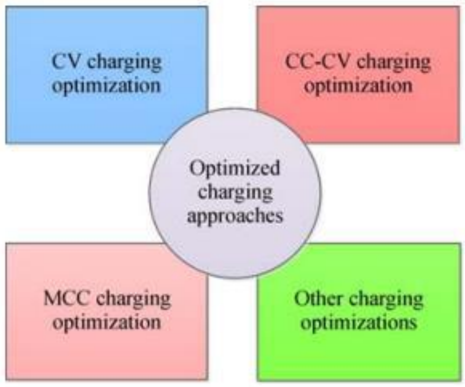

Figure 5. Charging approach

A reduced low-temperature electro-thermal model was proposed and validated by batteries with three cathode materials. This reduced model is accurate enough to develop fast heating and optimal charging approach under low temperature condition. Key technologies in the battery management system of electric vehicles temperature. Contact resistance is verified to play a vital role in battery temperature based on the analysis of this coupled model.

V. OPTIMIZATION OF CHARGING APPROACH

Based on the standard traditional charging, many optimized charging approaches have been developed to improve the charging performance of batteries in EVs recently. These optimizations of charging approach can be categorized as four fields.

The first field is the optimization of CV charging. Some approaches have been adopted to enhance the charging performance of standard CV charging. Objectives such as charging speed and temperature variation are considered in these approaches, a constant voltage with various restricting current approach is presented to limit the variation of battery temperature. Low battery temperature rise in total charging process is achieved by modulating the current rate of proposed approach. Lee and Park proposed a fast-charging control scheme in CV stage based on the battery internal impedance. In comparison with standard CV charging, battery charging speed becomes faster by using the developed control scheme.

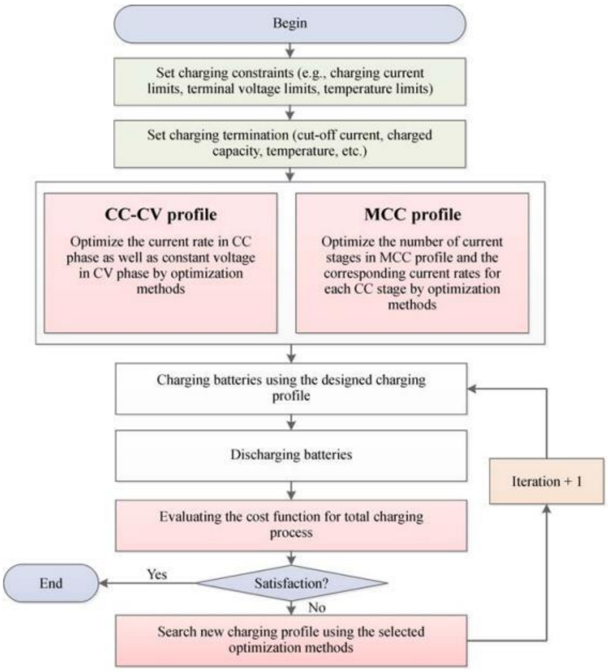

Figure 6. Charging optimization

Given that CC-CV charging and MCC charging are two simple and efficient charging approaches, numerous research have been developed to improve battery charging performance on the basis of CC-CV or MCC approach. The framework to improve the CC-CV/MCC charging approach.

For MCC charging optimization, the main and challenging target is to determine the number of current stages in MCC profile and the corresponding current rates for each CC stage. One popular approach to improve MCC charging performance is the fuzzy logic technology. the fuzzy logic controller is utilized to convert the charging quality characteristics (charging time and normalized discharged capacity) into a single fuzzy dual-response performance index, and a five-stage MCC charging pattern is optimized to improve charging efficiency.

VI. CONCLUSION

Key technologies in the BMS of EVs have been reviewed in this presentation, especially in the fields of battery modelling, state estimation and battery charging. Battery modelling together with the estimations of battery internal states and parameters play a vital role in revealing a hologram of battery operating status in the applications of EVs firstly. After capturing these key states, suitable battery charging approach can be designed to protect battery against damages, improve efficiency of energy conversion, and prolong the battery lifetime. However, most of the key technologies in the BMS are achieved and validated in specific test conditions. The modelling, estimation and charging performance in real-world applications that would be different from the test conditions, or in a worse-case scenario, is difficult to guarantee. Therefore, to explore the limitations or to develop a confidence interval of the presented algorithms and approaches are required to tackle this challenging issue. Where in this way we are developing the system model for battery management in electric vehicle by controlling the crucial parameters such as voltage, current, state of charge, state of health, state of life, temperature. It is every important that the BMS should be well maintained with battery reliability and safety. This present paper focusses on the study of BMS and optimizes the power performances of electric vehicles. Moreover, the target of reducing the greenhouse gases can greatly be achieved by using battery management system. And even the current market and growth forecast of hybrid EV is really promising and could be considered as a great prospect of the future.

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