Design, Development and packing of Lithium Ion Battery Pack for Electric Vehicles

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Abstract

Electric vehicles (EVs) have gained significant traction in recent years due to their eco-friendliness and energy efficiency. The Lithium-ion battery (LIB) is the most popular type of rechargeable battery used in EVs due to its high energy density, longer lifespan, and low self-discharge rate. The design, development, and packaging of Lithium-ion Battery Packs (LBP) are crucial to the performance, safety, and cost-effectiveness of electric vehicles. The design of LBP involves selecting the appropriate battery cells, determining the number of cells required, and configuring them in series or parallel connection to achieve the desired voltage and capacity. The selection of battery cells is based on factors such as energy density, power density, cycle life, and cost. The LBP must also be designed to fit the specific requirements of the EV, including its size, weight, and power output. The development of LBP involves testing and validating the design using advanced simulation software and experimental testing. This includes testing for factors such as temperature control, thermal management, and safety features such as overcharge and over-discharge protection. The packaging of LBP involves designing the enclosure for the battery pack, including insulation, cooling, and protection from external damage. The packaging design must also meet regulatory safety standards and be optimized for weight and cost. The LBP packaging must also be easily accessible for maintenance and replacement of battery cells. Overall, the design, development, and packaging of Lithium-ion Battery Packs for Electric Vehicles require a multidisciplinary approach, combining expertise in mechanical, electrical, and chemical engineering. These efforts aim to improve the performance and safety of electric vehicles while reducing their cost and environmental impact. As *the demand for electric vehicles continues to grow, advancements in LBP design and development are critical to meeting the evolving needs of the market.*

Keywords: *Battery, Lithium Ion Battery, Electric vehicle, Carbon emission*

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Introduction

In recent years, the global automotive industry has been undergoing a significant transformation as electric vehicles (EVs) continue to gain traction. The need to reduce carbon emissions and address climate change concerns has led to a surge in demand for EVs, and with it, the demand for advanced Lithium-ion Battery Packs (LBPs) that power these vehicles. LBPs are the key components that determine the performance, range, and cost of EVs. Therefore, designing, developing, and packaging LBPs for EVs have become critical areas of research and development for the automotive industry[1-3].

LBPs are rechargeable battery packs that use Lithium-ion technology to store energy. They are used in various applications, including smartphones, laptops, and electric vehicles. The Lithium-ion battery technology offers high energy density, longer lifespan, and low self-discharge rate compared to other battery technologies. These features make them ideal for use in EVs, where energy density and range are crucial[4-6].

Designing an LBP for an EV requires selecting the appropriate battery cells, determining the number of cells required, and configuring them in series or parallel connections to achieve the desired voltage and capacity. The selection of battery cells is based on factors such as energy density, power density, cycle life, and cost[7]. The LBP must also be designed to fit the specific requirements of the EV, including its size, weight, and power output. The design process must consider factors such as the battery's thermal management, which can affect the battery's performance, safety, and lifespan.

The development of an LBP for an EV involves testing and validating the design using advanced simulation software and experimental testing. This includes testing for factors such as temperature control, thermal management, and safety features such as overcharge and over-discharge protection. The LBP must also be tested for durability and reliability in various driving conditions and environments[8-11]. Additionally, the development process must consider the safety regulations and certifications required by the automotive industry.

The packaging of an LBP for an EV involves designing the enclosure for the battery pack, including insulation, cooling, and protection from external damage. The packaging design must also meet regulatory safety standards and be optimized for weight and cost. The LBP packaging must also be easily accessible for maintenance and replacement of battery cells. Furthermore, the packaging design must consider the impact on the vehicle's overall weight, which can affect the EV's energy consumption and range[12-15].

In recent years, there have been significant advancements in LBP design, development, and packaging for EVs. Research efforts are focused on improving the energy density, charging time, and lifespan of the battery cells, as well as developing innovative thermal management systems to improve safety and performance. Additionally, there is a growing emphasis on using sustainable materials in the battery production process, reducing the environmental impact of battery production and disposal[16-18].

Overall, designing, developing, and packaging LBPs for EVs require a multidisciplinary approach, combining expertise in mechanical, electrical, and chemical engineering. These efforts aim to improve the performance and safety of electric vehicles while reducing their cost and environmental impact[19-21]. As the demand for electric vehicles continues to grow, advancements in LBP design and development are critical to meeting the evolving needs of the market.

Methodology

The stages of battery pack assembling are broadly classified into the preparation stage, Assembly stage, and Test stage as shown in Figure 1. These stages are further divided into several steps as it is involved in the assembling of the battery pack as (i) Procurement of components (ii) Cell preparation (iii) Welding (iv) BMS installation (v) Wiring (vi) Insulation (vii) Casing (viii) Testing (ix) installation.

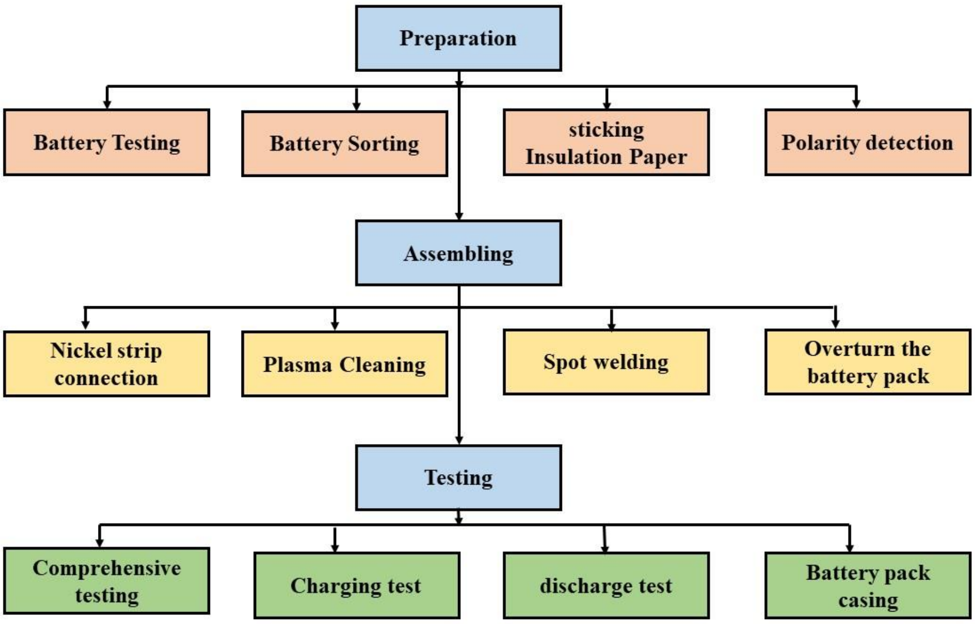


Figure 1. Methodology of battery assembling

Procurement of components: The first step in assembling a battery is to procure all the necessary components, including cells, BMS, wiring, insulation materials, and casing.

Cell preparation: The cells need to be prepared by cleaning them, checking their voltage and capacity, and arranging them according to the battery pack configuration.

Welding: The cells need to be welded together to create the desired voltage and capacity. The welding process needs to be done carefully to avoid overheating and damaging the cells.

BMS installation: The battery management system (BMS) needs to be installed to monitor the battery pack's voltage, temperature, and state of charge. The BMS also helps to protect the battery pack from overcharge and over-discharge.

Wiring: The wiring needs to be done to connect the cells and the BMS. The wiring needs to be done carefully to avoid short circuits and ensure a reliable connection.

Insulation: The battery pack needs to be insulated to prevent any electrical contact with the casing and to protect the battery from external elements such as moisture and dust.

Casing: The battery pack needs to be enclosed in a casing for protection and to ensure that it fits securely in the electric vehicle.

Testing: The assembled battery pack needs to be tested to ensure that it meets the desired performance and safety requirements. The testing includes evaluating the battery pack's voltage, capacity, and temperature under different operating conditions.

Installation: Once the battery pack has been tested and verified, it needs to be installed in the electric vehicle. The installation needs to be done carefully to ensure that the battery pack is securely mounted nd connected to the electric vehicle's wiring[22].

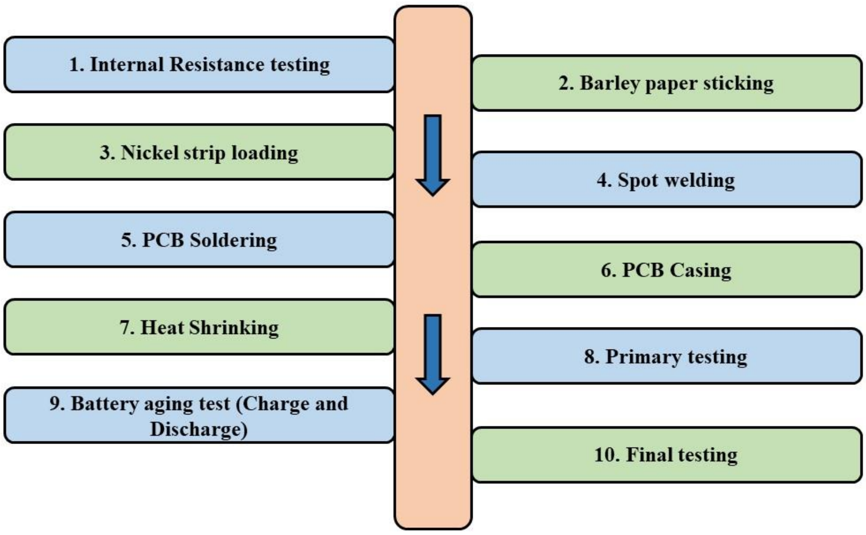


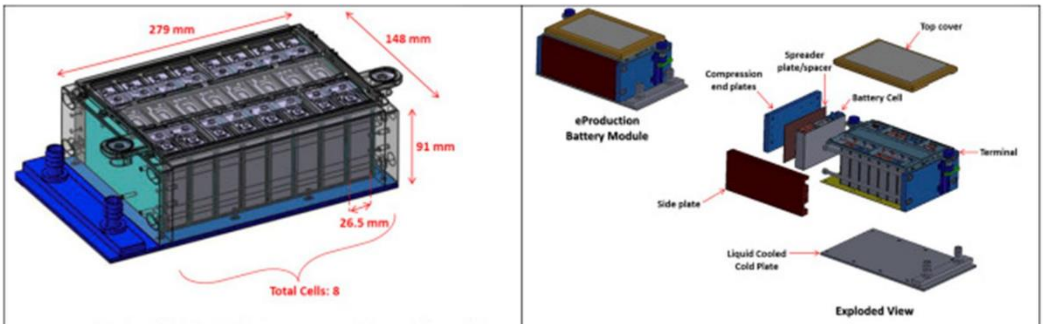
Figure 2. Process of assembling Lithium ferro phosphate battery pack

Battery Management system

A battery management system (BMS) is an essential component in an electric vehicle (EV) that is responsible for managing the battery pack's performance and safety. The BMS monitors and controls the battery pack's charging and discharging processes, ensuring that it operates efficiently and safely. It is responsible for maintaining the battery pack's state of charge (SOC) within safe limits, preventing overcharge, over-discharge, and overheating. The BMS also plays a crucial role in extending the battery pack's lifespan by ensuring that each cell within the pack operates within the manufacturer's specified limits. By monitoring each cell's voltage, current, and temperature, the BMS can detect any abnormalities or imbalances that may affect the battery pack's performance and safety. Additionally, the BMS provides the driver with real-time information about the battery pack's SOC, range, and health, enabling the driver to plan their journeys more efficiently[23].

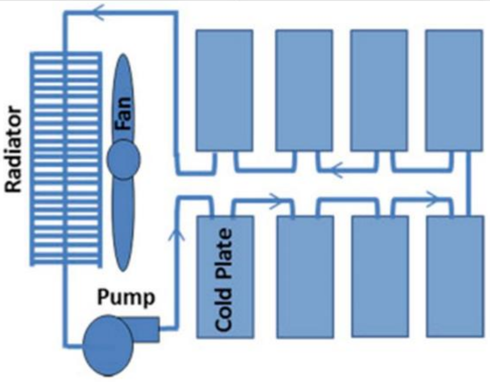
Thermal Management System

The thermal management system (TMS) of an electric vehicle (EV) battery pack is crucial for ensuring the battery operates safely and efficiently as shown in Figure 3. The TMS helps regulate the battery's temperature, preventing overheating or freezing, which can damage the battery and reduce its lifespan. The TMS is composed of several components, including a cooling system and a heating system. The cooling system uses a liquid or air to cool the battery when it is operating under high loads or high temperatures[24]. The heating system helps warm up the battery during cold weather conditions, which can cause the battery's performance to drop. The TMS works by monitoring the battery's temperature and adjusting the cooling or heating systems accordingly. If the battery temperature rises above a certain threshold, the TMS activates the cooling system to lower the temperature. If the temperature drops below a certain level, the heating system is activated. A well-designed TMS can improve the EV's performance, increase the battery's lifespan, and enhance safety. A poorly designed TMS as shown in Figure 4 can result in reduced range, decreased battery life, and increased risk of battery failure making it an essential technology for the growing EV market[25].



(a) Individual battery module with cold plate (reference/baseline system)

(b) Exploded view of existing system



(c) Schematic of complete cooling system configuration

Figure 3 Thermal management system

Results and Discussion

Battery Tester is mainly used to detect whether the parameters such as cell capacity, magnification and cycle times meet the use requirements. The positive electrode of the battery is pasted with insulating highland barley paper to protect the battery. The lithium battery sorter can be set to multiple gears through the upper and lower limits of internal resistance. The resistance is adjustable, and the adjustment mode is diversified and fast. It is equipped with an imported voltage internal resistance tester, integrated PC, high-end drive, all electric motor configuration; Process detection signal comprehensive and bid farewell to a single industrial machine. CCD tester has higher efficiency and accuracy in detecting whether the batteries are correctly placed in series-parallel positive and negative electrodes and in detecting products with defects in spot welding. Spot welding machine is mainly used for welding the battery and nickel strip in the cylindrical battery assembly as shoun in Figure 4. The welding pulse width as the function of two-stage current detection and comparison, sound and light alarm for abnormal current, effectively preventing the occurrence of false welding and false welding. It has the function of fault self diagnosis, displaying the corresponding fault points and facilitating maintenance. BMS tester is a multifunctional protection board tester is mainly used to test whether the functional indexes of the power battery protection board are within the parameter range, so as to provide a set of testing standards for the staff.

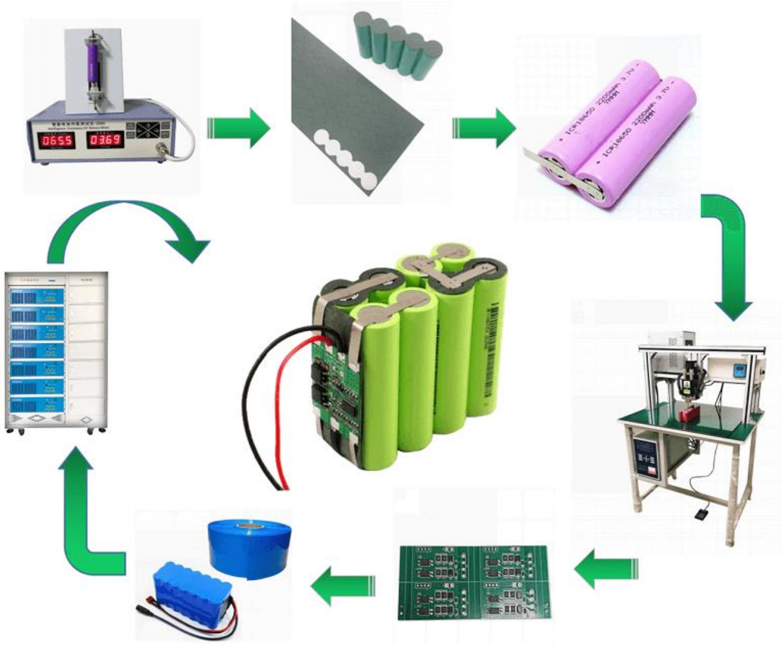


Figure 4. Detailed assembly processing

PVC Heat Shrinking Machine is used for shriking the PVC of battery pack. Ink jet printer is used for Code Printing on the Battery Pack. The aging cabinet is mainly used for testing the charging and discharging cycle of finished lithium batteries.

The Samples of developed battery pack is shown in figure 5. The final packed battery ready for delivery is shown in figure 6.

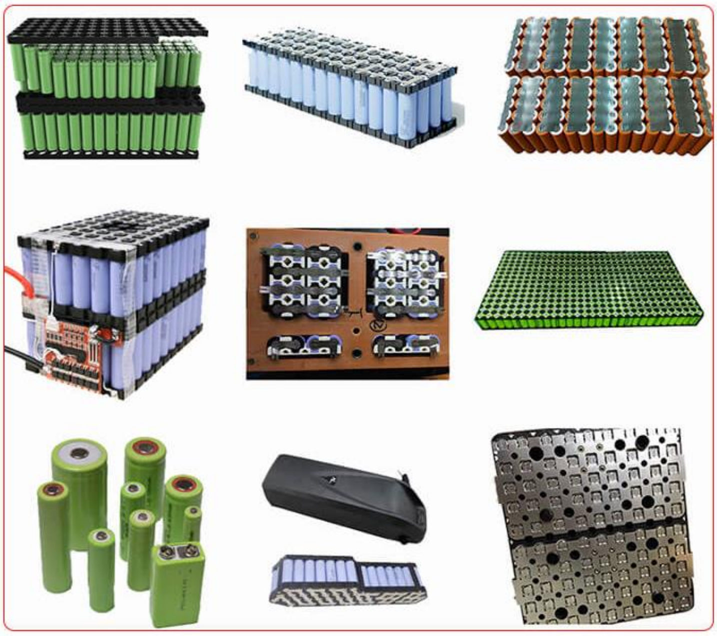


Figure 5. Samples of developed battery pack

Figure 6. Final tested battery pack

CONCLUSION

In conclusion, the design, development, and packaging of Lithium-ion Battery Packs (LBPs) are crucial to the performance, safety, and cost-effectiveness of electric vehicles (EVs). The Lithium-ion battery technology offers high energy density, longer lifespan, and low self-discharge rate compared to other battery technologies, making it ideal for use in EVs. Designing an LBP for an EV involves selecting the appropriate battery cells, determining the number of cells required, and configuring them in series or parallel connections to achieve the desired voltage and capacity. The development of an LBP involves testing and validating the design using advanced simulation software and experimental testing. The packaging of an LBP involves designing the enclosure for the battery pack, including insulation, cooling, and protection from external damage. All these stages require multidisciplinary expertise and must meet safety regulations and certifications required by the automotive industry. Advancements in LBP design and development are critical to meeting the evolving needs of the market. Research efforts are focused on improving the energy density, charging time, and lifespan of the battery cells, as well as developing innovative thermal management systems to improve safety and performance. Additionally, sustainable materials are being used in the battery production process to reduce the environmental impact of battery production and disposal. As the demand for EVs continues to grow, LBPs' design, development, and packaging must continue to improve. These efforts will not only improve the performance and safety of electric vehicles but also reduce their cost and environmental impact, making EVs a more viable and sustainable transportation option for the future.

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