Design process and performance evaluation of Lithium ferro Phosphate battery for the application to transport sector

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Abstract:

The transition towards electric vehicles (EVs) is gaining momentum as governments and industry players around the world prioritize reducing carbon emissions. The battery pack is one of the most critical components of an EV, and its design and development are key factors in achieving better performance, safety, and cost-effectiveness. This paper presents the design and development of a lithium iron phosphate (LiFePO4) battery pack for an electric vehicle. LiFePO4 batteries have gained popularity for their high energy density, long cycle life, and safety, making them excellent aspirant for EV applications. The paper highlights the design considerations, including the battery pack configuration, cell arrangement, and thermal management system. The battery pack is designed to meet the power and energy requirements of an electric vehicle and to ensure safety and reliability. The development process involves selecting the appropriate components and testing the performance of the battery pack. The battery pack is tested under various conditions, including discharge rate, capacity, and temperature, to evaluate its performance. The results demonstrate that the LiFePO4 battery pack is a viable and efficient power source for EVs. In conclusion, the design and development of a LiFePO4 battery pack for an electric vehicle has been successfully demonstrated in this paper. The LiFePO4 battery pack is shown to be a feasible and reliable option for powering electric vehicles, and it has the potential to contribute significantly to the reduction of carbon emissions from the transportation sector.

Keywords:*Battery, Lithium ferro phosphate, Electric vehicle, Carbon emission*

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Introduction

The automotive industry is witnessing a significant shift towards electric vehicles (EVs) as governments and industry players worldwide prioritize reducing carbon emissions. The battery pack is one of the most crucial components of an electric vehicle, and its design and development are critical factors in achieving better performance, safety, and cost-effectiveness.Currently, lithium-ion batteries are the most widely used battery technology in EVs, but they have some drawbacks such as limited lifespan, high cost, and safety concerns. Therefore, alternative battery technologies such as Lithium ferro phosphate (LiFePO4) batteries have gained popularity for their high energy density, long cycle life, and safety. LiFePO4 batteries have a higher thermal and chemical stability than other lithium-ion batteries, making them a viable option for EV applications.This paper presents the design and development of a LiFePO4 battery pack for an electric vehicle. The paper discusses the design considerations, development process, and performance evaluation of the LiFePO4 battery pack.

The design of the LiFePO4 battery pack is a critical factor in achieving better performance, safety, and cost-effectiveness. The battery pack design includes the configuration, cell arrangement, and thermal management system.The battery pack configuration includes the number of cells, their arrangement, and the overall size of the battery pack. The number of cells determines the voltage and capacity of the battery pack, and their arrangement affects the battery pack's efficiency and safety. The overall size of the battery pack is also a crucial factor as it affects the weight and space utilization of the electric vehicle.The cell arrangement is another critical factor in battery pack design. The cells need to be arranged in a way that maximizes the battery pack's efficiency and safety. The cells should be arranged in a way that minimizes internal resistance, reduces thermal hotspots, and ensures uniform cell temperature.Thermal management is another critical aspect of battery pack design. LiFePO4 batteries are sensitive to temperature, and high temperatures can lead to reduced performance and shortened lifespan. Therefore, an efficient thermal management system is necessary to maintain the battery pack's temperature within the optimal range. The thermal management system includes cooling and heating systems, such as liquid cooling or air cooling, to regulate the battery pack's temperature.The development process involves selecting the appropriate components and testing the performance of the battery pack. The selection of components, such as the battery management system (BMS), charger, and other electrical components, is crucial in achieving the desired performance and safety of the battery pack.The testing of the battery pack involves evaluating its performance under various conditions, including discharge rate, capacity, and temperature. The battery pack is tested under different driving scenarios to evaluate its range and efficiency. The testing also includes safety tests such as overcharge and over-discharge tests to ensure the battery pack's safety.The performance of the LiFePO4 battery pack is evaluated based on its energy density, power density, cycle life, and safety. The energy density of the battery pack determines the driving range of the electric vehicle, while the power density determines the acceleration and overall performance of the vehicle. The cycle life of the battery pack determines its lifespan and maintenance requirements.Safety is a crucial factor in battery pack performance evaluation. LiFePO4 batteries have a higher thermal and chemical stability than other lithium-ion batteries, but they still need to be protected from overcharge, over-discharge, and overheating. The battery pack should have safety features such as a BMS and safety switches to prevent these incidents.

Design considerations

In this proposed system, a 60V 24Ah LiFePO4 battery is designed. When designing a 60V 24Ah lithium ferro phosphate battery, there are several important considerations to keep in mind. Here are some of the most important factors to consider:

Voltage: The battery must be designed to provide a nominal voltage of 60V, with a maximum voltage of around 72V and a minimum voltage of around 54V.

Capacity: The battery must have a capacity of 24Ah, which is the amount of energy it can store and deliver. This capacity should be sufficient to power the device for the required duration.

Chemistry: Lithium ferro phosphate (LiFePO4) chemistry should be used, as it offers high safety, long cycle life, and good performance at high temperatures.

Cell Configuration: The battery should be configured using individual LiFePO4 cells, each with a nominal voltage of around 3.2V. This would require 19 cells in series to achieve a total voltage of 60V.

Cooling: Proper cooling mechanisms must be implemented to maintain the operating temperature of the battery within a safe range. This is especially important for high power applications.

Enclosure: The battery should be housed in a sturdy and durable enclosure that can protect it from damage and also prevent exposure to environmental hazards such as water or dust.

Charging: A suitable charging mechanism must be incorporated, capable of charging the battery to its maximum voltage without overcharging or damaging the cells.

Discharging: The battery must be designed to provide a stable and consistent output voltage during discharge. This would require appropriate circuitry and controls to ensure that the output voltage stays within a safe range.

Monitoring: Monitoring circuitry should be included to measure the battery's voltage, current, and temperature. This data can be used to optimize battery performance and prevent overcharging or over-discharging.

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.

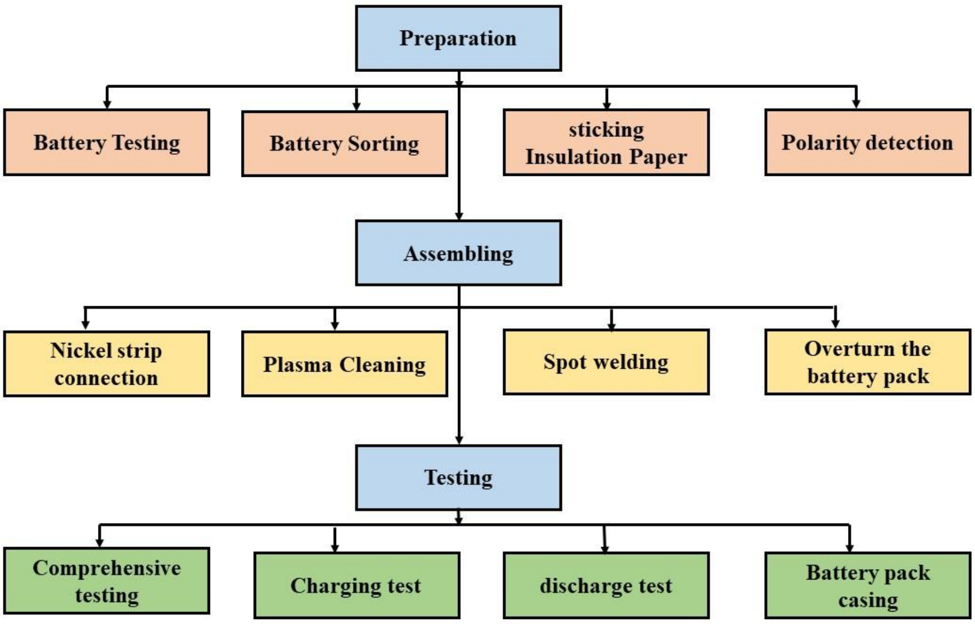

Figure 1. Methodology of battery assembling

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 shortcircuits 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.

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 and connected to the electric vehicle's wiring.

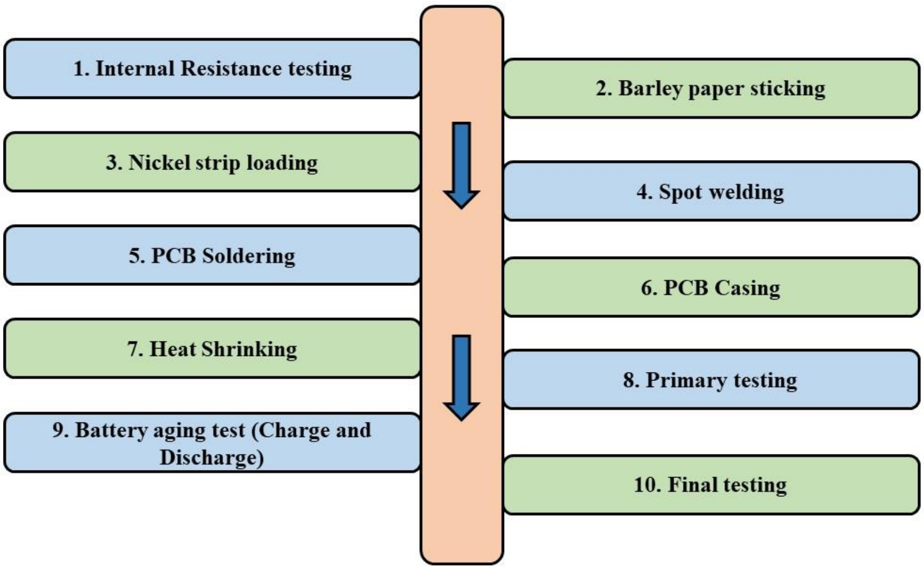

Figure 2. Process of assembling Lithium ferro phosphate battery pack

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. It also provides diagnostic information to the EV's onboard computer and alerts the driver to any faults or malfunctions in the battery pack or charging system.As the demand for EVs increases, the importance of BMS technology as shown in Figure 3 will continue to grow.

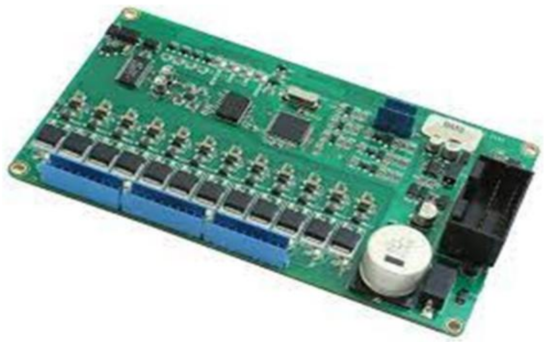

Figure 3: Battery management system

Testing 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 machineis mainly used for welding the battery and nickel strip in the cylindrical battery assembly. The welding pulse width is adjustable, the welding spatter is small, and the welding spot is not discolored. It has 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.

The main test items include: open circuit voltage, AC internal resistance, discharge test, discharge over-current test, short circuit protection test, charging test and charging protection test.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 4. The performance evaluation of the proposed batteryis shown in figure 5.

Figure 4. Samples of developed battery pack

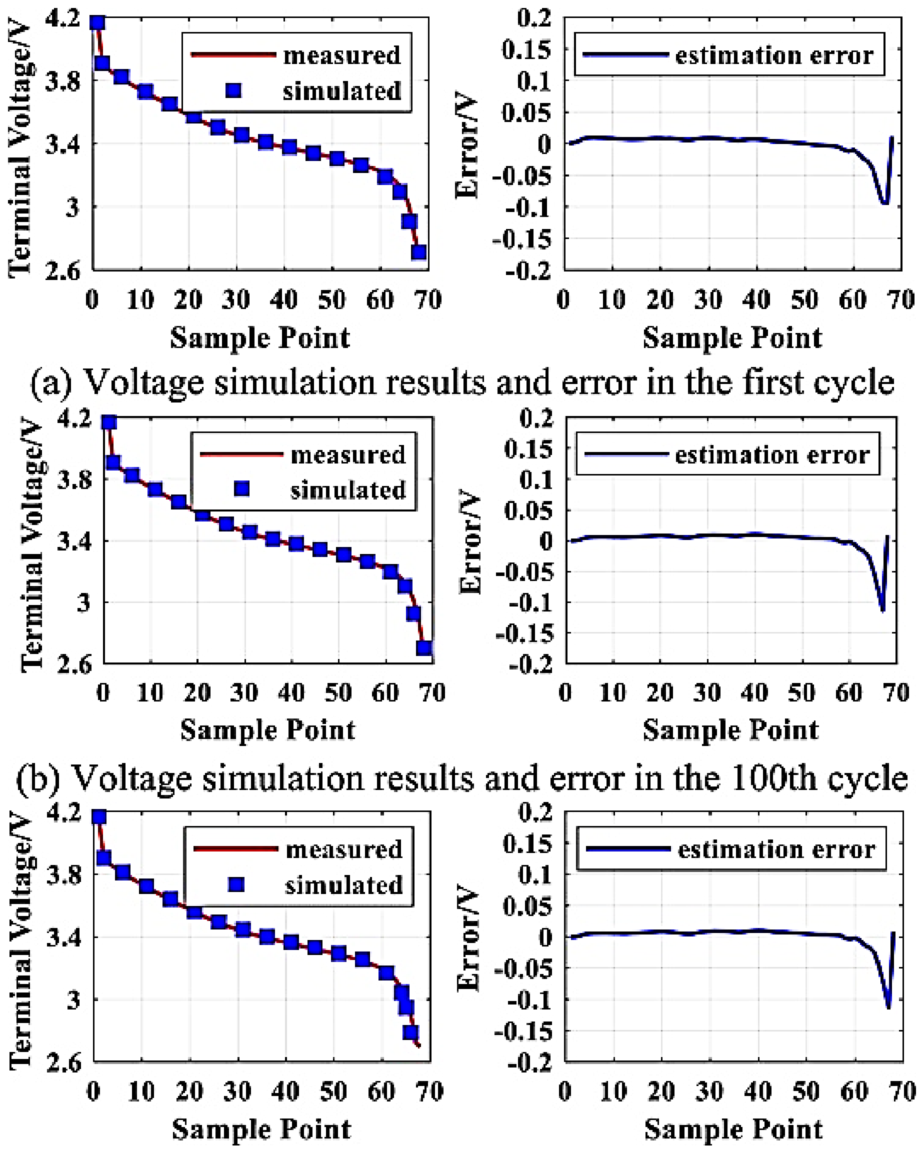

Figure 5. Performance evaluation

CONCLUSION

The first pertains to the design of a battery pack for the proposed electric vehicle model and a consideration of its performance and prototyping. The basic parameters and design of a 60V battery pack using cylindrical battery cells wascompleted to meet the electrical and mechanical design requirements. The battery pack consists of13 stacking submodules of 20 cells connected in parallel to achieve designing configuration. The conductivity of current connectors in thebattery submodule and the welding joints between different cell units were checked. The layoutand fixed structure of the battery submodule were designed to accommodate passive air coolingfor weight reduction.The second topic involved testing, characterization and modeling of a 280 Ah prismatic batterycell of high capacity. In conclusion, the design and development of a 60V 24Ah Lithium ferro phosphate (LFP) battery pack for electric vehicles (EVs) is an important area of research and development in the EV industry. A well-designed LFP battery pack can offer several benefits to EV manufacturers and drivers, including increased range, improved safety, and reduced maintenance costs. The successful development of a 60V 24Ah LFP battery pack will contribute to the wider adoption of EVs in mainstream society, which can help reduce carbon emissions and contribute to a more sustainable future. The challenges associated with designing and developing such a battery pack, such as managing thermal performance and optimizing energy density, underscore the importance of ongoing research in this area.

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