

DESIGN AND DEVELOPMENT OF ADVANCED BATTERY COOLING SYSTEM WITH WIRELESS CHARGING

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Abstract: Advanced Battery Cooling System that integrates wireless charging and liquid cooling capabilities. The battery cooling system is crucial in maintaining the performance and health of batteries used in electric vehicles, portable devices, and renewable energy systems. The wireless charging system eliminates the need for cords and connectors, making it easier to charge hard-to-reach equipment. With a Battery Cooling System that integrates these features, the overall efficiency of electric vehicles could be improved, ultimately extending the life of the battery and increasing its performance. Our goal is to develop a simple, low-cost wireless charging system, a cooling system for battery packets, and a battery cooling system to increase the overall efficiency of electric vehicles by increasing the battery's performance.

Keywords: Battery Cooling System, Wireless charging, Liquid cooling system.

I. INTRODUCTION

The Battery cooling system plays an important role in Electric vehicles by improving Efficiency and long Life span. The wireless charging system for charging Electric vehicles in advanced technique avoids the use of cables for charging and fast charging. By cooling system of battery we can achieve a good temperature stability .

The Battery cooling System plays a crucial role in ensuring the optimal functioning of the battery pack by monitoring its state, controlling charging and discharging processes, and protecting against overvoltage, undervoltage, and overheating conditions. In this context, the development of advanced electric remote-control vehicles presents an exciting opportunity to enhance their performance, efficiency, and reliability. In comparison to the wire method of Electric charging the wireless method has more advantages like without human interaction , more durable than cables.

This paper aims to design and develop a comprehensive Battery cooling system specified for electric remote-control vehicles, and innovative features to optimize battery performance and prolong lifespan. We particularly used air cooling and liquid cooling methods for electric vehicles because they have advantages of compact structure and ease of arrangement with long life and durability of battery performance.

The Battery cooling system module plays a critical role in managing the series-connected battery cells, balancing cell voltages, and protecting against overcharging and over discharging events. Additionally, the wireless charging coil enables convenient and cable-free charging of the battery.

II. PROBLEM DEFINITION

Nowadays the popularity of EVs has increased and problems with the battery have arisen in the charging and handling of the battery packs. There are recommended current and voltage restrictions for charging and draining each type of battery. Overriding these limits may result in oxidation and a short circuit, harming the battery and reducing its lifespan. The worst-case scenario could involve an electric shock, fire, or explosion shock.

III. SOLUTION FOR THE PROBLEM

A battery cooling system is an important component of any battery-powered system, as it helps to ensure the safe and efficient operation of the battery. Liquid cooling is also a common technique used to manage the temperature of batteries and improve their performance.

When it comes to battery swapping mechanisms, incorporating a liquid cooling system within the system can provide several benefits. Firstly, it can help to reduce the heat generated during the battery swapping process, which can improve the safety and reliability of the system. Secondly, it can help extend the batteries' lifespan by keeping them at a consistent temperature range. Finally, it can improve the charging efficiency of the batteries, as they can be charged

more quickly at lower temperatures.

To implement such a system, the Battery cooling system would need to be designed to communicate with the liquid cooling system, so that it can monitor and regulate the temperature of the batteries. The liquid cooling system would likely involve a series of tubes or channels through which a coolant fluid would flow, drawing heat away from the batteries. This coolant fluid would need to be carefully chosen to ensure that it is compatible with the batteries and can operate safely within the system.

Overall, incorporating a liquid cooling system into a battery swapping mechanism can provide a range of benefits, including improved safety, performance, and lifespan of the batteries. However, it would require careful design and integration with the Battery cooling system to ensure that the system operates effectively and reliably.

IV. DESIGN AND FABRICATION

A. Battery pack

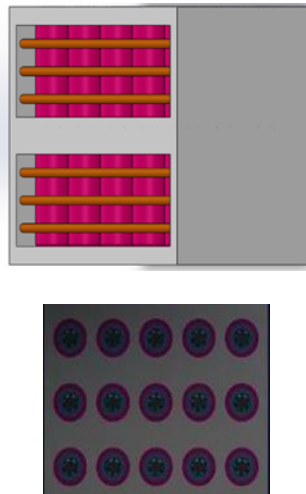


Figure IV.A CAD Design of battery pack

The dimensions of the 18650 lithium-ion battery cells were meticulously measured and carefully noted down. These cells are widely used in various applications due to their compact size and high energy density.

To create a battery pack, a specific configuration was designed using these 18650 cells. This configuration was chosen to optimize the overall performance and capacity of the battery pack.

Next, a CAD (Computer-Aided Design) model was developed based on the measured dimensions of the cells. The CAD model served as a virtual representation of the battery pack, allowing for precise design and evaluation before moving to the physical production stage. Once the CAD model was finalized, it was used to generate a CAD file, which served as the input for 3D printing. Using advanced additive manufacturing techniques, the battery case was 3D printed layer by layer, creating a durable and custom-designed housing for the battery pack. The 3D printing process provided flexibility in design, enabling the incorporation of specific features and structural integrity required for the battery pack. By following this comprehensive process of measuring, designing, and manufacturing, a battery pack with optimized dimensions and a customized case was successfully created.

B. Heat dissipation system

The battery case is specifically engineered to address the issue of heat generated during fast charging or discharging. To facilitate effective heat dissipation, the case is equipped with a network of copper tubes. These tubes, measuring 0.6mm in diameter, are strategically positioned to ensure maximum contact with the battery.

The copper tubes are interconnected through a series of pipes. The main pipe is connected to a liquid tank, and a pump is employed to circulate the coolant liquid throughout the system. This coolant acts as a heat transfer medium, absorbing the heat generated by the battery. The coolant, now carrying the absorbed heat, flows through the copper tubes.

As it comes into contact with the hot battery, the heat is transferred from the battery to the coolant. The heated coolant then proceeds to a heat exchanger, where the heat is dissipated into the surrounding environment.

To enhance the cooling process further, the battery system incorporates a fan, positioned on the side of the battery pack.

These fans are securely fixed to the battery pack and actively contribute to the cooling process. By creating a flow of air over the battery and heat dissipation tubes, the fans help dissipate heat more rapidly, thus improving overall cooling efficiency.

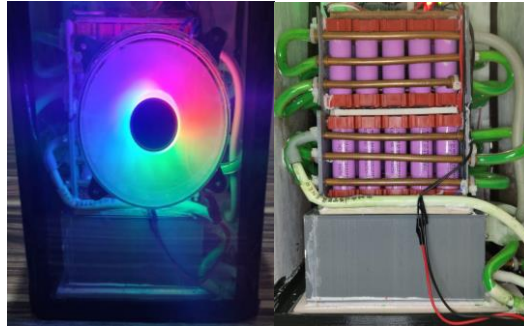


Figure IV.B Heat dissipation system

The combined operation of the coolant circulation system, copper tubes, heat exchanger, and fans results in effective heat dissipation for the battery. This helps to maintain the battery's temperature within safe limits during fast charging or discharging operations, reducing the risk of overheating and prolonging the battery's lifespan.

By employing this well-designed heat dissipation system, the battery pack can function optimally, delivering reliable performance and enhanced efficiency, while ensuring the safety and longevity of the battery.

C. Wireless charging pad

The first step in developing the wireless charging system was to accurately measure the size of the wireless coil. Additionally, precise dimensions of both the transmitting and receiver coils were taken. These measurements served as crucial specifications for the subsequent design process.

Using the gathered specifications, the base for the charging pad was meticulously designed. This involved utilizing computer-aided design (CAD) software to create a detailed model of the charging base pad. The CAD model allowed for precise positioning and alignment of the coils within the base, ensuring optimal charging efficiency.

Once the CAD design was finalized, the next step involved bringing the design to life through 3D printing.



The CAD file was used to instruct a 3D printer, which then used the provided information to manufacture the physical base for the wireless charging system. 3D printing enabled the creation of complex shapes and intricate details with high accuracy.



Figure IV.C Designed wireless charging base

By following this design and manufacturing process, the wireless charging system was able to deliver convenient and reliable charging capabilities. The combination of accurate measurements, CAD design, and 3D printing allowed for the creation of a functional and aesthetically pleasing charging base pad.

V. DESIGN OF ELECTRIC CIRCUIT

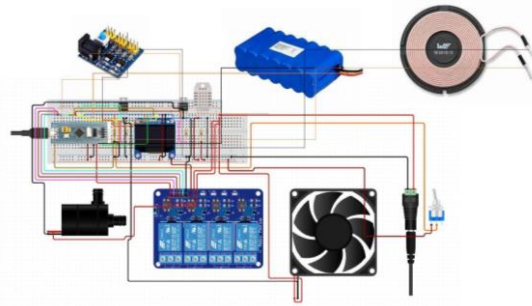


Figure V.A. Circuit diagram

The circuit is designed to incorporate various components for efficient temperature monitoring and control within the battery pack. To facilitate and control of the coolant pump and fans, relay modules are utilized.

The wireless charging system is also integrated into the circuit. A display is incorporated into the system to provide visual feedback and information. This comprehensive setup, utilizing the STM microcontroller and various components, enables precise temperature monitoring, control of the coolant pump and fans, wireless charging management, and informative display functionality within the battery pack system.

VI. DESIGN AND ASSEMBLY

A. Design and assembly of the system

The initial stage of the process involved designing the outer casing in CAD software, ensuring that it could accommodate all the necessary components and systems within the final block. This CAD design served as a blueprint for the fabrication process.

Next, the CAD model was transformed into a physical object by fabricating Wooden board material. The wood board was carefully cut and shaped to match the dimensions and contours of the CAD design, resulting in a fabricated box that replicated the intended outer casing.

Once the fabricated box was ready, all the components and systems were meticulously assembled inside it. This included integrating the battery pack, cooling system, charging circuit, and other relevant components according to the design specifications.

Through this assembly process, the final product was developed, with all the components neatly fitted within the fabricated box. The result was a fully functional and integrated system housed within the designed outer casing.

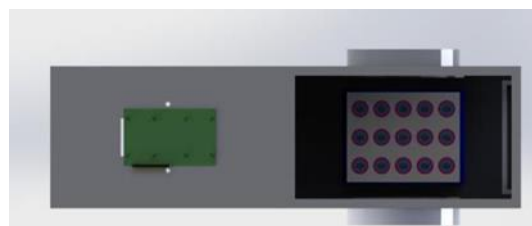


Figure VI.A CAD Design of the system

B. Design and assembly of vehicle

The vehicle chassis or body is constructed using wood, providing strength and durability to the structure. The motors

and wheels are securely attached to the body, allowing for proper propulsion and movement.

To control the speed of the vehicle, a RF CONTROLLER (Pulse Width Modulation) controller is implemented. This controller regulates the power supplied to the motors, enabling variable speed control and smooth acceleration/deceleration.

For power supply, an DC connector jack is incorporated, providing a secure and reliable connection point between the vehicle and the batteries. The DC connector jack ensures efficient power transfer and reduces the risk of disconnection during operation.



Figure VI.B. Vehicle with controller

Overall, with the wooden structure, fixed motors and wheels, RF CONTROLLER controller for speed control, and the DC Connector jack for battery connection, the vehicle is equipped with a sturdy and efficient design for reliable performance and control.

VII. CALCULATIONS

STATE OF CHARGE (SoC) CALCULATIONS

$$\text{SoC} = Q / Q_{\text{max}}$$

Where: Q = Remaining capacity Q_{max} = Rated capacity

$$\text{SoC} = (78.7\%)/(99.5\%) \times 100 \quad \text{SoC} = 79.09\%$$

STATE OF HEALTH (SoH) CALCULATIONS

$$\text{SoH} = Q_{\text{max}} / C_r \times 100$$

Where: Q_{max} = The charge available of the battery C_r = The rated capacity

$$\text{SoH} = (99.5\%)/(100\%) \times 100$$

$$\text{SoH} = 100\%$$

VIII. RESULTS

The final working model showcases the integrated battery system, which incorporates a liquid cooling system and wireless charging functionality. Additionally, the model includes the vehicle itself and a display that provides crucial battery parameters. This comprehensive setup allows for efficient temperature management, convenient charging, and real-time monitoring of battery parameters for optimal performance and maintenance

The final working model showcases the liquid cooling system which incorporates a liquid cooling system and wireless charging functionality. This comprehensive setup allows for efficient temperature management, convenient charging, when battery temperature exceeds 32 degree celsius sensor sends signal to stm32 which enables relay to activate and send signal to activate fan and cooling system.



Figure VIII. Final project

IX. CONCLUSIONS

In our paper we have developed a battery cooling system, which enables an efficient mechanism for cooling of battery. We also developed a system for charging without wires at a reasonable price. The performance of the battery has been improved with the liquid cooling and also with faster wireless technique.

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