International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 03 | Mar 2024 www.irjet.net p-ISSN: 2395-0072

ACTIVE BATTERY PACK COOLING SYSTEM USING PELTIER MODULE

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Abstract - *Our project is Active Battery Pack Cooling System using Peltier Module. It is Electric Vehicles battery pack cooling system which tends to maintain a constant temperature inside a battery pack system. In this project we are going to increase the lifecycle of batteries and increase the quality of the batteries in Electric Vehicles. Nowadays electric vehicle plays a major role in automotive industry. Electric Vehicles use power to charge their batteries as opposed to utilizing non-renewable energy sources like petroleum or diesel. Electric vehicles are more productive, and that joined with the power cost implies that charging an electric vehicle is less expensive than filling petroleum or diesel for your movement prerequisites. But in Electric Vehicles, batteries are getting busted due to sudden increase of temperature. For this problem statement we made a solution. When the temperature inside a battery pack is suddenly increases, it gets explode. So we need to maintain a constant temperature inside the battery pack system. For that, we add a module called Peltier module(Thermoelectric) to the battery pack system. This module works on the principle of both cooling and heating process. It also works like a coolant. When it is summer season, we need to cool a battery, if it is winter season, we need to heat a battery to certain temperature. That is what we use the Peltier module. This system will work only on 12v DC. So it is very helpful to increase our battery's lifecycle. This module will work on more type of batteries like lithium-ion batteries and lithium- potassium ion batteries.*

Keywords: *Active cooling, battery pack, Peltier module, Electric vehicle, thermoelectric, coolant, temperature, lithium Ferro phosphate.*

1. INTRODUCTION

An active battery pack cooling system using Peltier modules is a high-tech way to control and maintain battery pack temperature in various applications, including renewable energy storage systems, electric vehicles (EVs), and portable electronics. This novel method actively transfers heat away from the battery pack 0using the thermoelectric effect made possible by Peltier modules. This ensures ideal operating conditions and prolongs the life of the batteries. Among the myriad challenges faced by battery systems, one critical aspect is the effective management of temperature, a factor that profoundly influences performance, longevity, and safety. However, the best performance from these battery packs depends on maintaining exact temperature settings; high temperatures can damage performance, hasten depreciation, and even be dangerous, which emphasizes how important thermal management is. The evolution of cooling systems even though they are widely used, traditional passive cooling techniques frequently fail to dynamically adjust to the changing demands and environmental circumstances that batteries encounter. Active cooling systems are a result of the search for a more intelligent and responsive solution. They are made to actively control temperature and mitigate the negative consequences of heat build-up. Peltier modules, also known as thermoelectric coolers, are semiconductor devices that exploit the Peltier effect to create a heat transfer mechanism. A temperature difference is produced when heat is absorbed on one side of the module and released on the other when an electric current passes through it. Peltier modules are perfect for applications involving thermal management since they actively cool or heat surfaces using this concept. The active battery pack cooling system integrates Peltier modules into its design to actively control the temperature of the battery pack. This is important since battery cell performance and lifetime are directly impacted by temperature. High temperatures have the potential to quicken chemical processes inside the cells, which could result in decreased capacity, quicker deterioration, and safety issues. There are numerous benefits of integrating

Peltier modules into active cooling systems. These include increasing battery cell longevity, boosting general performance, and boosting safety a crucial factor in applications like electric automobiles. The system's adaptability to different battery chemistries, dynamic reactivity, and reasonably small size all add to its appeal to a wide range of sectors.

2. LITERATURE SURVEY

Angelo Maiorino (2023) explores the development of efficient Electric Vehicles (EVs) and the importance of thermal management systems for Lithium-ion batteries. He compares academic studies with the automotive industry's thermal engineering state of art. He analyzes nine EV models and their development, focusing on the quality and quantity of data available on manufacturers' official sites and specialist journals. The review concludes by examining future perspectives on thermal management of battery packs.

Gang Zhao and Xiaolin Wang (2022) found that liquid-cooling battery thermal management systems (BTMS) are an efficient thermal management solution for electric vehicles (EVs). They reviewed recent research on design improvement and optimization, focusing on coolant channel, heat transfer jacket, cold plate, and liquid cooling- based hybrid system improvements. They found that cooling channel, refrigerant cooling, and liquid-PCM hybrid cooling improvements were most effective.

Seham Shahid (2022) explores the thermal runaway process in lithium-ion batteries, a potential energy source for electric vehicles. The paper reviews key aspects of thermal runaway, including initiation mechanisms, propagation, and gas characterization. It discusses the development of mathematical and numerical models to predict thermal runaway, effective battery thermal management systems, and mitigation strategies to minimize damage during thermal runaway.

Zhi Xu's (2022) study investigates the impact of inlet position and air velocity on the cooling performance of battery packs in electric vehicles. The mechanism of the influences of inlet position and inlet air velocity on the cooling performance of the battery pack is revealed. The results show that the maximum temperature decreases by 4.17 K at 30 mm inlet position, and by 8.5-18.5 K with increasing inlet air velocity. The study provides valuable guidelines for improving battery pack cooling design.

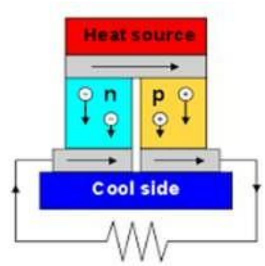
3. OBJECTIVE AND METHODOLOGY

The objectives our project is to maintain optimal battery temperature, to improve battery performance, to enhance battery safety and to optimize energy consumption and Cost-effective solution.

Our product is unique without any external coolant and we are reducing the battery temperature using novel idea. This prototype uses Peltier module TEC1-12706. As we know it works based on see-beck effect. Once rated temperature is set prescribed in the manufacturer datasheet controller, it compares the actual temperature of battery pack using NTC 10K resistance. Totally we are using 2 NTC to take the average temperature variation of the pack. The set point for our battery pack was 30degree Celsius when temperature goes beyond this value, controller triggers the fan and Peltier. The supply to the Peltier was fed in one direction so that hot side will be hot and cold side will be cold. And the speed of the fan will be minimum which can be seen in the DSO. When the temperature increased, the PWM will be increased to cool down the pack. This will be happen for the temperature drop but the current direction for the Peltier will be reversed. The overall circuit is controlled by PIC16f877A controller.

WORKING PRINCIPLE:

See-beck effect - A phenomenon known as the See-beck effect occurs when two distinct semiconductors or electrical conductors have different temperatures, which causes a voltage differential between the two materials.



4. CONTRIBUTION

The contribution for the successful completion of an active battery pack cooling system utilizing Peltier modules has been divided into three parts.

One focused on selecting efficient Peltier modules to maximize cooling capacity. To choose the ideal Peltier module configurations based on cooling capacity, power consumption, and cost constraints.

7. RESULT AND DISCUSSION

Our project active battery pack cooling system using Peltier module is successfully developed and tested. The system demonstrated the ability to keep the battery temperature within the desired target range under various operating conditions.

We designed the prototype in proteus software and is shown below.

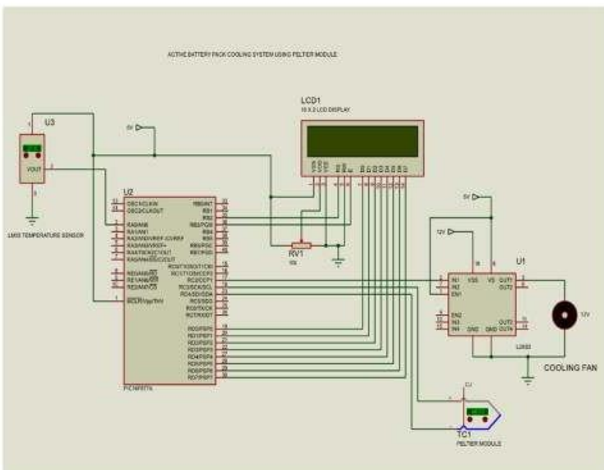


Figure 1 - Design of prototype in Proteus software

The images of our project active battery pack cooling system using Peltier module is shown below.

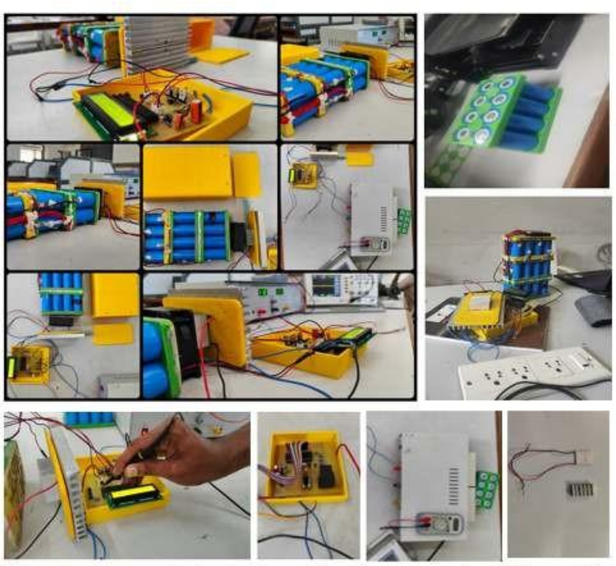


Figure 2 – Images of Active battery pack cooling system using Peltier module

- **Enhanced Battery Life:** The system can considerably increase the battery's lifespan by maintaining it at optimal temperatures. More charge cycles are possible due to reduced battery degradation at lower temperatures.
- **Improved Battery Performance**: When batteries are used within optimal temperature ranges, they function better. Consistent power output and avoidance of performance drops due to overheating are guaranteed by the cooling system.
- **Enhanced System Reliability:** Safety risks and system failures can result from overheating. By reducing these hazards, active cooling can help creating a battery system that is more dependable.

The image of active battery pack cooling system maintained at an optimal temperature range and 3D printing is shown below.

Figure 3 – System maintained at optimal range

Figure 4 – 3D printing

8. CONCLUSION

Our project has been successfully developed, tested and evaluated an active battery pack cooling system using Peltier module. Using Peltier modules, this study effectively built and assessed an active battery pack cooling system. our project investigated the feasibility of using Peltier modules for active battery pack cooling. The outcomes show how this strategy may be used to enhance battery safety and performance. Depending on the particular needs, Peltier module-based cooling may be a good option for a variety of applications by weighing the trade-offs between cost, power consumption, and efficiency. The battery pack's temperature was lowered to the appropriate level while taking energy consumption and system viability into account. The battery pack's temperature has been successfully managed within the intended range by the integration of Peltier modules, sophisticated control algorithms, and carefully chosen components. This has resulted in improved performance and longevity. All things considered, our research offered insightful information about the possibility of utilizing Peltier modules for battery pack cooling, advancing the creation of more effective and environmentally friendly battery systems.

9. SUGGESTIONS FOR FUTURE WORK

To further improve the active cooling of the battery pack, there are some suggestions which includes to investigate other cooling techniques (such as heat pipes) for particular situations where a larger cooling capacity or efficiency may be necessary. Look into using more sophisticated Peltier modules that utilize less power or have higher efficiency. Provide a user interface that allows you to keep an eye on system performance and modify cooling settings in real time. Create control strategies that adapt to the environment and battery usage patterns to optimize cooling. Investigate more recent Peltier modules with a greater coefficient of performance as technology develops. This increases the system's overall efficiency by enabling more cooling with fewer power usage.

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