Liquid Cooling System Design for EV Battery

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Abstract - Li-ion batteries have emerged as one of the most alluring energy sources, particularly in the transportation industry, as worries about carbon emissions and the ensuing climate effects grow. An efficient thermal management system is necessary for Li-ion batteries in order to guarantee high efficiency, prevent capacity degradation, and remove safety concerns. Heat pipe-based thermal management systems have been widely utilized to regulate the temperature of Li-ion batteries because they can provide exceptional cooling performance in a small area. Based on research conducted over the previous 20 years, this study provides a thorough evaluation of the thermal management systems of Li-ion batteries that use four different types of heat pipes: flat single channel heat pipes, oscillating heat pipes, flexible heat pipes, and microchannel heat pipes. To give researchers and engineers a comprehensive understanding, the impacts of many influencing factors on the cooling performance and thermal runaway behavior of Li-ion batteries are covered in detail. According to the findings, water spray cooling has the potential to outperform forced air cooling and water bath cooling for all kinds of heat pipe-based thermal management systems. Its energy usage is also clearly lower than that of forced air cooling.

Key Words: Li-ion Battery Cells, Battery Thermal Management, External Cooling, Electrical Vehicle, Thermal Analysis, Battery Pack, Heat Dissipation, Cold plates.

1.INTRODUCTION

The most widely used cooling technology is liquid cooling. The battery is cooled by a liquid coolant, such as ethylene glycol, water, or a refrigerant. The liquid transfers heat to a different area, like a radiator or heat exchanger, via tubes, cold plates, or other parts that encircle the cells. Direct electrical contact between the cells and the liquid coolant is avoided by components transporting the liquid. Liquid cooling is an active kind of cooling since it uses pumps, fans, and other equipment to actively remove and reroute heat. Statistics show that the transportation industry contributes more than 20% of the world's CO2 emissions. The most widely used cooling technology is liquid cooling. The battery is cooled by a liquid coolant, such as ethylene glycol, water, or a refrigerant. The liquid transfers heat to a different area, like a radiator or heat exchanger, via tubes, cold plates, or other parts that encircle the cells. Direct electrical contact between the cells and the liquid coolant is avoided by components transporting the liquid. Liquid cooling is an active kind of cooling since it uses pumps, fans, and other equipment to actively remove and reroute heat. Statistics show that the transportation industry contributes more than 20% of the world's CO2 emissions.Vehicles have been continuously electrified in recent decades due to the growing demands of reducing carbon emissions. Lithium-ion (Li-ion) batteries are better than other batteries for electrified cars, such as electric vehicles (EV) and hybrid electric vehicles (HEV), because of its high voltage, good discharging characteristics, energy density, and dependability. Li-ion batteries are therefore the most popular energy source for electric cars. Heat is produced during the Li-ion battery's charging and draining procedures. The irreversible heat produced by side reactions, polarization resistance, and Ohmic resistance, as well as the reversible heat produced by electrochemical processes and entropy change, make up the overall amount of heat produced. Therefore, in the absence of a heat removal technique, the temperature of Li-ion batteries will steadily rise. In order to prevent heat buildup in Li-ion batteries, particularly for high power Li-ion batteries used in electric vehicles, a thermal management system is necessary. Heat will move from Li-ion batteries to heat pipes in the evaporator portion, and the liquid in the wick structure will change from a liquid to a gas. After passing through the adiabatic zone, the evaporated liquid enters the condensation area. The vapor will transform back into liquid in the condensation portion as the heat from the heat pipe escapes to the outside.

2. LITERATURE SURVEY

1] Minggao Ouyang and Jiuyu Du External Liquid Cooling Technique for Ultra-Fast Charging of Lithium-Ion Battery Modules November 2022 In order to solve the temperature rise problems during ultrafast charging, this research suggests an external liquid cooling technique for lithium-ion battery modules. To examine the cooling impacts of this technique under a range of circumstances, such as charging rates, cooling plate layouts, coolant temperature, and flow rate, the study runs extensive tests and simulations.
2]Harish Rasool, Shahada Ajman, and Atila Sen. A Novel Dual-Sided Cooling System Design Concept for SIC Automotive Inverters Using Additive Manufacturing November 2024 An inventive dual-sided cooling system design approach for SiC automobile inverters using additive manufacturing is presented in this research. The main goal is to overcome 3D metal printing's manufacturing constraints in order to create a small, dependable, and lightweight cold plate in a single unit. 3] Berkeley University For electric vehicle charging, a bidirectional liquid-cooled GAN-based AC/DC flying capacitor multilevel converter with integrated startup and additional cold plate manufacturing. March 2022 A bidirectional liquid-cooled Gann-based AC/DC flying capacitor multi-level (FCML) converter for electric vehicle (EV) charging applications is designed and implemented in this work.

3. OBJECTIVE

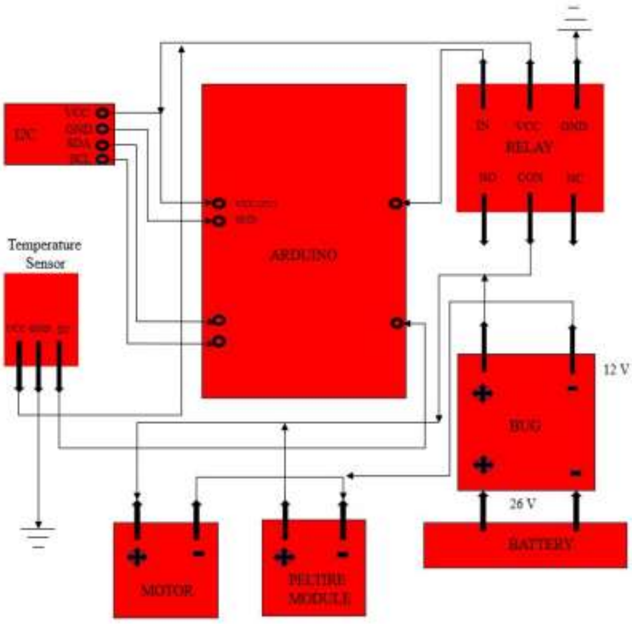
1. Temperature Regulation: For maximum performance, longevity, and safety, keep batteries at their ideal temperature, which is normally between 20 and 40°C.
2. Enhanced Efficiency: Improve the lifespan, capacity, and performance of batteries.

3.Decreased Thermal Runaway Risk: Avoid safety hazards associated with overheating.
4. Cost-Effectiveness: Reduce system expenses without sacrificing dependability.
5. Reliability: Make sure there is little maintenance and a high system uptime.
6. Better Battery Health: Reduce deterioration and increase battery life.

4.PROBLEM STATEMENT

Liquid cooling is an active cooling method since it uses pumps, fans, and other parts to actively remove and reroute heat. charging/discharging cycles, minimize thermal runaway risk, and enhance battery performance, efficiency, and lifespan." Liquid cooling is the most popular cooling technology. It uses a liquid coolant such as water, a refrigerant, or ethylene glycol to cool the battery. The liquid goes through tubes, cold plates, or other components that surround the cells and carry heat to another location, such as a radiator or a heat exchanger. Components carrying the liquid prevent direct electrical contact between the cells and the liquid coolant. Because liquid cooling involves pumps, fans, and other devices to actively extract and redirect the heat, it is an active form of cooling.

5. BLOCK DIAGRAM



6. HARDWARE COMPONENTS


Arduino Uno


LCD Display


Peltier Kit


Relay


Motor


Buck Converter

7. Advantages

1.Better Heat Transfer: Compared to air, liquid coolants absorb heat more effectively.
2.Greater Cooling Capacity: Higher heat loads can be handled by liquid cooling.
3. Less Variability in Temperature: Liquid cooling keeps temperatures steady.
4. Quieter Operation: Fan noise is eliminated by liquid cooling.
5. Less Vibration: Component vibration is reduced by liquid cooling.
6.Extended Component Lifespan: Thermal stress is decreased by liquid cooling.
7. Protection against Corrosion: Liquid coolants help prevent corrosion.
8. Decreased Buildup of Dust Dust accumulation is reduced by sealed liquid cooling systems.
9. Lower Power Consumption: Fan power consumption can be decreased with liquid cooling.
10. Enhanced Efficiency: System performance per watt is optimized by liquid cooling.

8. CONCLUSION

The most important factor in ensuring safe, effective, and dependable operating and riding experiences in electric vehicles (EVs) is the liquid cooling system for the battery. An EV's overall range can be increased by up to 15% by employing a liquid cooling system for its batteries, which effectively regulates temperature and extends battery life by up to 50% while increasing charging efficiency by up to 20%. This technology effectively lowers the risk of thermal runaway, allowing the battery to be charged at high power and achieving optimal battery performance in extremely hot or cold temperatures.

9. REFERENCES

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