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Comparative Study of Air Cooling and Water Cooling for Electric Vehicle Battery Thermal Management System

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Abstract-- **Electric vehicles (EVs) require efficient battery thermal management to maintain safe operating temperatures and improve battery life. Excessive heat generation during battery operation can reduce efficiency and may cause safety issues. This research presents a comparative study of air cooling and water cooling techniques used in Battery Thermal Management Systems (BTMS). An experimental setup was developed using a metal block to simulate battery heat generation with the help of a heating coil. Temperature sensors, W1209 temperature controllers, plastic cooling fans, and mini water pumps were used in the system. Experimental observations indicate that water cooling provides better heat dissipation compared to air cooling, although air cooling is simpler and more economical.**

Keywords-- **Electric Vehicle, Battery Thermal Management System, Air Cooling, Water Cooling, Temperature Control**

I. INTRODUCTION

Electric vehicles are gaining popularity due to their environmental benefits and energy efficiency. However, one of the major challenges in EV technology is the thermal management of battery systems. During charging and discharging cycles, batteries generate heat due to internal resistance and chemical reactions. If this heat is not properly controlled, battery performance and lifespan may decrease. Battery Thermal Management Systems (BTMS) are used to maintain battery temperature within a safe range.

II. LITERATURE REVIEW

Previous research studies highlight the importance of effective battery thermal management in electric vehicles. Air cooling systems are commonly used because they are simple and cost-effective, while liquid cooling systems offer better heat transfer capability due to higher thermal conductivity of liquids compared to air.

III. COMPONENTS USED

W1209 Temperature Controller, 12V DC Motor, Plastic Cooling Fan, Digital Temperature Meter, 12V Mini Water Pump, Metal Block (Battery Simulation), Heating Coil, 12V Power Supply.

IV. EXPERIMENTAL SETUP

A metal block was used to simulate the EV battery pack. A heating coil generated heat in the metal block. Two cooling systems were implemented: an air cooling system using a plastic fan and a water cooling system using a mini water pump to circulate water around the heated block.

V. WORKING PRINCIPLE

When the temperature rises above the preset value, the temperature controller activates the cooling system. In the air cooling system, the fan removes heat through airflow. In the water cooling system, circulating water absorbs heat from the heated metal block and reduces its temperature.

VI. RESULTS AND DISCUSSION

Experimental observations indicate that water cooling reduces temperature faster than air cooling. However, air cooling is simpler, cheaper, and easier to maintain.

VII. CONCLUSION

This study compared air cooling and water cooling techniques for EV battery thermal management. The results show that water cooling provides better heat dissipation, while air cooling remains a cost-effective and simple solution for small-scale systems.

REFERENCES

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Function: Comparative Study of Air Cooling and Water Cooling for Electric Vehicle Battery Thermal Management System

Objective:

To evaluate and compare the performance, efficiency, and feasibility of air cooling and water cooling methods for maintaining optimal battery temperature in electric vehicles.

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Inputs:

- Battery specifications (capacity, chemistry, size)
- Cooling method (air cooling / water cooling)
- Environmental conditions (ambient temperature, humidity)
- Operating parameters (charging rate, discharge cycles, thermal load)

Process:

1. Implement air cooling using forced convection (fans, ducts).
2. Implement water cooling using liquid coolant circulation (channels, plates, pumps).
3. Record battery temperature distribution, cooling rate, and energy consumption.
4. Analyze performance under varying load and climate conditions.
5. Compare results for efficiency, cost, safety, and scalability.

Outputs:

- Temperature regulation efficiency
- Impact on battery performance and lifespan
- Energy consumption of cooling system
- Cost-benefit analysis
- Suitability for different categories of EVs