Thermal Management of Lithium-Ion Battery in Electric Vehicles

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Abstract — For lithium-ion (Li-ion) battery packs used in electric drive vehicles (EDVs), selecting the best cooling technique, and developing an effective cooling control strategy are crucial for enhancing safety, extending the pack's service life, and lowering costs. The ideal temperature range for such battery packs is 15°C to 35°C. Trade-offs must be considered when selecting a cooling technology and creating strategies, including those involving prices, complexity, weight, cooling effects, temperature uniformity, and performance. This study compares the outcomes with static cell temperature while considering two cell-cooling techniques: air cooling and direct liquid cooling. Using a typical big-capacity Li-ion pouch cell made for EDVs, these techniques are evaluated for their effectiveness in terms of coolant parasitic power consumption, maximum.

Keywords: Battery, Liquid Cooling, Fluid Body, Terminals, Heat, Flow, Battery Thermal Management System, Electric Vehicles, Phase Change Material

I. INTRODUCTION

Because of their high energy efficiency, lithium-ion (Li-ion) batteries are increasingly the battery of choice for EV designers. However, rapid temperature changes cause these batteries to lose efficiency. Liquid cooling, an effective thermal management technique that prolongs battery pack service life, is one means to reduce temperature increases (whether ambient or created by the battery itself). Multiphysics simulation is a tool that engineers can use to investigate liquid cooling in batteries and improve thermal management. Because of their high energy density, lengthy lifespan, and low rate of self-discharge, lithium-ion batteries have a wide range of applications. They are becoming the standard battery for electronics because of their growing importance in applications ranging from portable devices to grid energy storage. Choosing the best cooling method and creating a cooling control strategy to maintain the ideal temperature range of 15°C to 35°C are essential for improving safety, extending the pack's service life, and reducing costs for lithium-ion (Li-ion) battery packs used in electric drive vehicles(EDVs).

If batteries have more energy, can go farther, and are less expensive, the market for energy-saving and environmentally friendly electric drive vehicles (EDVs) will grow more. For lithium-ion (Li-ion) battery packs in electrical vehicles (EVs) and hybrid electrical vehicles (HEVs), a battery thermal management system that maintains the temperature at an ideal range of 15°C to 35°C is crucial to extending lifetime and guaranteeing operating safety. The battery pack produces a lot of heat while the car is running that needs to be vented. The increased demand for gravimetric and volume energy in EDVs has made it difficult to remove the generated heat and maintain a consistent temperature. Many cooling strategies have been suggested and investigated.

A. Problem Statement

Choosing an acceptable cooling technique for a lithium-ion (Li-ion) battery pack for electric powered power automobiles (EDVs) and making a most beneficial cooling approach to maintain the temperature at a most effective vary of 15 °C to 35 °C is imperative to growing safety, extending the pack provider life, and decreasing costs. When selecting a cooling approach and creating strategies, trade-offs want to be made amongst many elements such as costs, complexity, weight, cooling effects, temperature uniformity, and parasitic power.

B. Objective

- To decrease the temperature of the battery effectively.
- To reduce the cost of cooling systems used in electric vehicles.
- Cooling systems need to be able to keep the batterypack in the temperature range of about 15-35 degrees Celsius.
- Thermal and CFD analysis of concept battery model.

C. Scope

The most frequent battery kind in modern-day electric-powered cars is lithium-ion due to the fact of their excessive power density in contrast to they are weight. As of December 2019, the value of electric-powered automobile batteries has fallen 87% on account of 2010 on a per kilowatt-hour basis. Lithium-ion batteries have an excessive power-to-weight ratio, excessive electricity efficiency, and excellent high-temperature performance. In practice, this skill that the batteries preserve a lot of electricity for their Weight, which is quintessential for electric-powered vehicles – much less Weight skill the vehicle can journey similarly on a single charge. If the temperature inside the battery is too high, the lithium-ion cells get damaged, no longer preserve an awful lot of charge, and essentially naff you off. However, as many humans trip during the bloodless snap, the batteries both do no longer cost accurate or absolutely do no longer work, when uncovered to very bloodless temperatures so this evaluation on lithium-ion batteries will assist us in comprehending all these parameters.

D. Methodology

- Started the work with a literature survey.
- Searched many lookup papers from a range of articles and posted journal papers, accumulated the lookup papers, and segregated them as per assignment necessities.
- Studied in element the segregated journals and literature in a particular manner alongside the widespread reference books and tutorial books.
- Worked on specific Mechanisms that can be beneficial for this venture and checked the feasibility of making the experimental pattern inside finances alongside simulation cost.
- Detail design activity, 3D modelling completed.

- Battery cell meshing and fluid body meshing are done by ANSYS software.
- CAE results were analyzed and conclusions were made.

II. COMPONENT DESIGN

Component design of battery cell, and fluid body is done in NX 10 software.

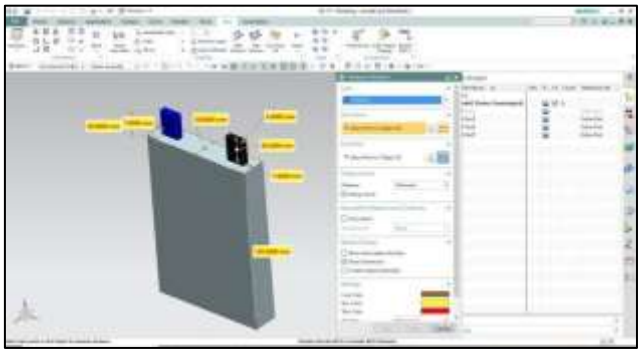

Fig. 1: Battery Cell Dimensions

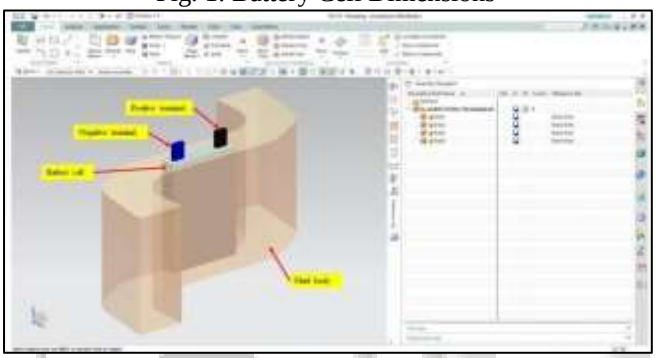

Fig. 2: Assembly of child parts

III. ANALYSIS OF BATTERY CELL

Part file meshing done using Ansys tool & CFD simulation done in Ansys Fluent software. Meshing and analysis details are as follows:

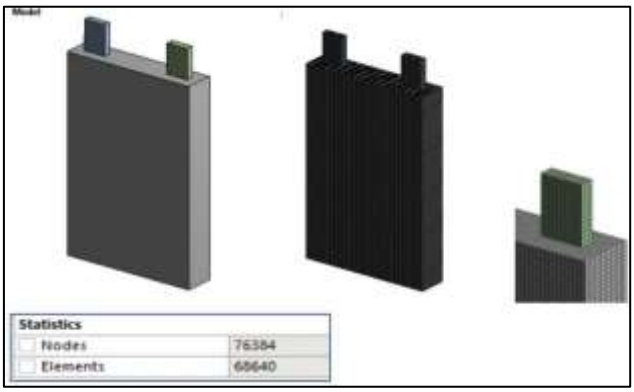

Fig. 3: Battery cell meshing

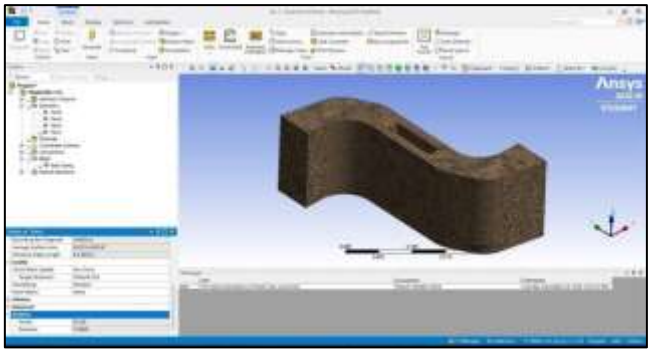

Fig. 4: Fluid geometry meshing

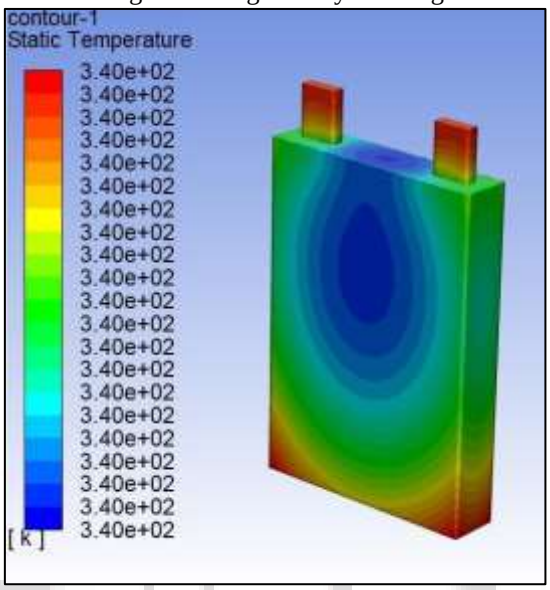

Fig. 5: Battery cell static temperature results

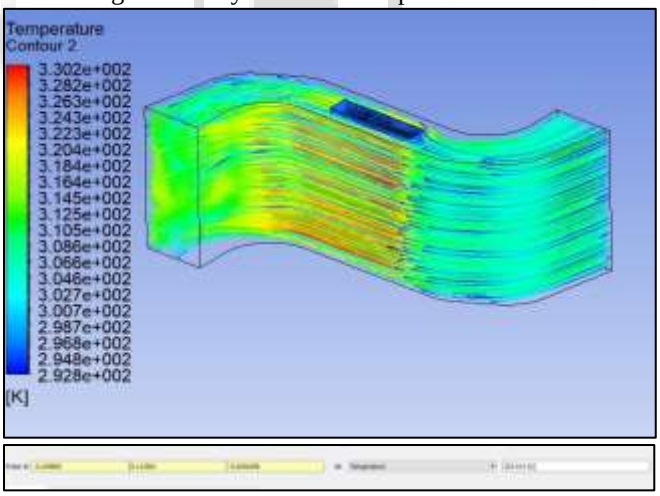

Fig. 6: Battery cell temperature with air as cooling media

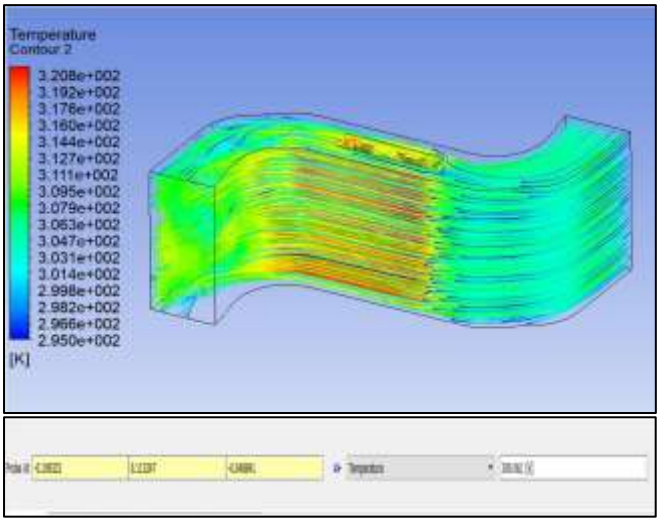

Fig. 7: Battery cell temperature with Liquid cooling (Ethanol glycol) media

IV. RESULTS COMPARISON

Sr. No.	Particulars	Temper Ature In Kelvin	Temperat Ure In °C	Δt In °C
1	Battery Cell Temperature In Static Condition	340	66.85	
2	Battery Cell Temperature WithAir As Cooling Medium	325.4	52.25	14.6
3	Battery Cell Temperature WithLiquid As CoolingMedium	309	35.85	35.85

From the above results, Battery cell cooling is more effective with a liquid cooling medium compared to an air-cooling medium

V. CONCLUSIONS

- In static circumstances battery cellphone temperature alongside terminals found up to 340K which is 66.85°C.
- When the fluid was handed via the battery walls, the battery mobile temperature dropped significantly.
- With air as a fluid media temperature of the battery cell dropped from 340K to 325.4K, which is 52.25°C. There is a temperature difference of approx. 14.6°C observed.
- With Ethanol glycol as a liquid media temperature of the battery cell is further dropped to 309K, which is 35.85°C.
- From the Analysis it is concluded that using ethanol glycol as a liquid media gives better thermal cooling of the battery cell, which ultimately results in better battery cell life, and battery efficiency and the battery can sustain for longer life.

REFERENCES

[1] "Critical review towards thermal management systems of lithium-ion batteries in electric vehicle with its electronic control unit and assessment tools" by C Kannan, R Vignesh, C Karthick B Ashok.
[2] "Experimental Investigation on a Thermoelectric Cooler for Thermal Management of a Lithium-Ion Battery Module" by Xinxi Li, Zhaoda Zhong, Jinghai Luo, Ziyuan Wang, This teamizhong Yuan, Guoqing Zhang, Chengzhao Yang, ChuxiongYang.
[3] "Thermal management of lithium-ion battery pack with liquid cooling" by l.h. Saw, a. A. O. Tay and l. Winston zhang.
[4] "A Detailed Review on Electric Vehicles Battery Thermal Management System" by Sourav Singh Katoch, M Eswaramoorthy.
[5] "Comparison of different cooling methods for lithium-ion battery cells" by Dafen Chen, Jiuchun Jiang, Gi-Heon Kim, Chuanbo Yang, Ahmad Pesaran.
[6] "Development of cooling strategy for an air-cooled lithium-ion battery pack" by Hongguang Sun, Regan Dixon.
[7] "A new concept of thermal management system in Li-ion battery using air cooling and heat pipe for electric vehicles" by Hamidreza Behi, Danial Karimi, Mohammadreza Behi, Morteza Ghanbarpour, Joris Jaguemont, Mohsen Akbarzadeh Sokkeh, Foad Heidari Gandoman, Maitane Berecibar, Joeri Van Mierlo.
[8] "Thermal management of Li-ion battery with phase change material for electric scooters: experimental validation" by Siddique A. Khateeba, Shabab Amiruddina, Mohammed Faridb, J. Robert Selmana, Said Al-Hallaj.
[9] "Electric vehicle battery thermal management system with thermoelectric cooling" by Y. Lyu a, A.R.M. Siddique a, S.H. Majid b, M. Biglarbegian a, S.A. Gadsden a, S. Mahmud.
[10] "Hybrid Battery Thermal Management System in Electrical Vehicles" by Chunyu Zhao, Beile Zhang, Yuanming Zheng, Shunyuan Huang, Tongtong Yan and Xiufang Liu.
[11] "Battery Thermal Management Systems: Current Status and Design Approach of Cooling Technologies" by Thomas Imre Cyrille Buidin and Florin Mariasiu.
[12] "Thermal Management of a 48 V Lithium-Ion Battery Pack by Semiconductor Refrigeration" by Rui Yang, Kuining Li, Yi Xie, Wei Li, Yuping Qian, Yangjun Zhangand Hongxiang Zhang.

