Thermal Management of Lithium-Ion Battery in Electric Vehicle

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Abstract - *Choosing a proper cooling method for a lithium-ion (Li-ion) battery pack for electric drive vehicles (EDVs) and making an optimal cooling control strategy to keep the temperature at an optimal range of 15degree C to 35degree C is essential to increasing safety, extending the pack service life, and reducing costs. When choosing a cooling method and developing strategies, trade-offs need to be made among many facets such as costs, complexity, weight, cooling effects, temperature uniformity, and performance. This paper considers two cell-cooling methods: air cooling, direct liquid cooling and compared the results with static cell temperature. To evaluate their effectiveness, these methods are assessed using a typical large capacity Li-ion pouch cell designed for EDVs from the perspective of coolant parasitic power consumption, maximum temperature rise, temperature difference in a cell, and additional weight used for the cooling system. Used a state-of-the-art Li-ion battery electro-chemical thermal model. The results show that under our assumption an air-cooling system consumed more energy to keep the same average temperature. A direct liquid cooling system has the lowest maximum temperature rise.*

***Key Words*: Battery, liquid cooling, fluid body, terminals, heat, flow, Battery thermal management system, electric vehicles, phase change material.**

1. INTRODUCTION

Lithium-ion (Li-ion) batteries are widely known for their energy efficiency and are becoming the battery of choice for designers of electric vehicles (EVs). However, these batteries lose efficiency quickly with sudden changes in temperature. One way to control rises in temperature (whether environmental or generated by the battery itself) is with liquid cooling, an effective thermal management strategy that extends battery pack service life. To study liquid cooling in a battery and optimize thermal management, engineers can use Multiphysics simulation. Li-ion batteries have many uses thanks to their high energy density, long life cycle, and low rate of self-discharge. That's why they're increasingly important in electronics applications ranging from portable devices to grid energy storage — and they're becoming the go-to battery for EVs and hybrid electric vehicles (HEVs) because of their high energy density compared to their weight. Choosing a proper cooling method for a lithium-ion (Li-ion) battery pack for electric drive vehicles (EDVs) and making an optimal cooling control strategy to keep the temperature at an optimal range of 15°C to 35°C is essential to increasing safety, extending the pack service life, and reducing costs

Energy-saving and environmentally friendly electric drive vehicle (EDV) adoption in the market is in- creasing and has more potential if batteries have more energy, travel longer, and are less expensive. The battery thermal management system to keep the temperature at an optimal range of 15°C to 35°C is essential for lithium-ion (Li-ion) battery packs in electrical vehicles (EVs) and hybrid electrical vehicles (HEVs) to extend lifetime and ensure operating safety. During vehicle operation, considerable heat is generated in the battery pack that needs to be rejected. How to remove the generated heat, and keep the temperature uniform has become a challenge because of the high requirement of gravimetric and volume energy in EDVs. Several cooling methods have been proposed and researched.

1.1 Problem Statement

Choosing a proper cooling method for a lithium-ion (Li-ion) battery pack for electric drive vehicles (EDVs) and making an optimal cooling control strategy to keep the temperature at an optimal range of 15 °C to 35 °C is essential to increasing safety, extending the pack service life, and reducing costs. When choosing a cooling method and developing strategies, trade-offs need to be made among many facts such as costs, complexity, weight, cooling effects, temperature uniformity, and parasitic power.

1.2 Objective

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

1.3 Scope

The most common battery type in modern electric vehicles is lithium-ion because of their high energy density compared to they're weight. As of December 2019, the cost of electric-vehicle batteries has fallen 87% since 2010 on a per kilowatt-hour basis. Lithium-ion batteries have a high power-to-weight ratio, high energy efficiency and good high-temperature performance. In practice, this means that the batteries hold a lot of energy for their Weight, which is vital for electric cars – less Weight means the car can travel further on a single charge. If the temperature within the battery gets too high, the lithium-ion cells get damaged, don't hold as much charge and basically naff you off. However, as many people experiencing during the cold snap, the batteries either don't charge properly, or simply don't work, when exposed to very cold temperatures so this analysis on lithium-ion battery will help us to know all this parameter.

1.4 Methodology

- Started the work with literature survey.
- Searched many research papers from various articles and published journal papers, collected the research papers and segregated as per project requirement.
- Studied in details the segregated journals & literatures in detailed manner along with the standard reference books and academic books.
- Worked on different Mechanisms that can be useful for this project & checked the feasibility of making the experimental sample within budget along with simulation cost.
- Detail design activity, 3D modelling completed.
- Battery cell meshing, fluid body meshing is done ANSYS software.
- CAE results analysed and conclusions were made.

2. COMPONENT DESIGN

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

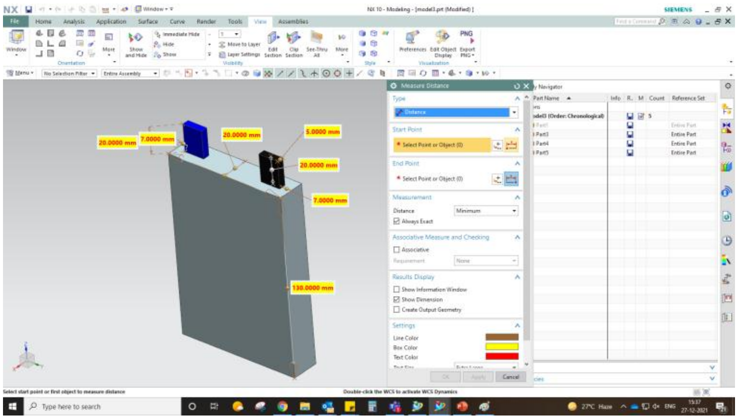


Figure 1: Battery Cell Dimensions

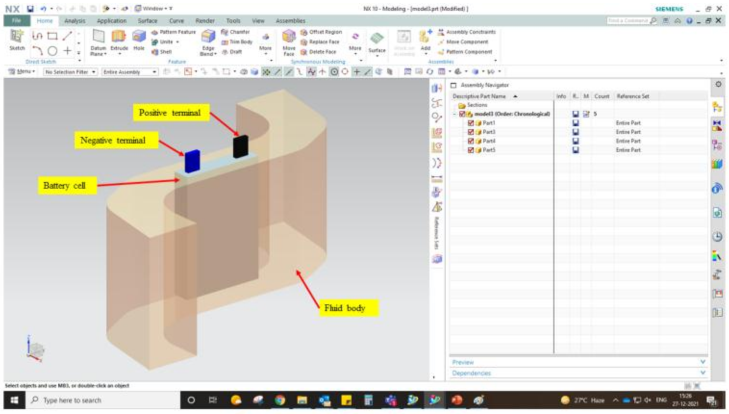
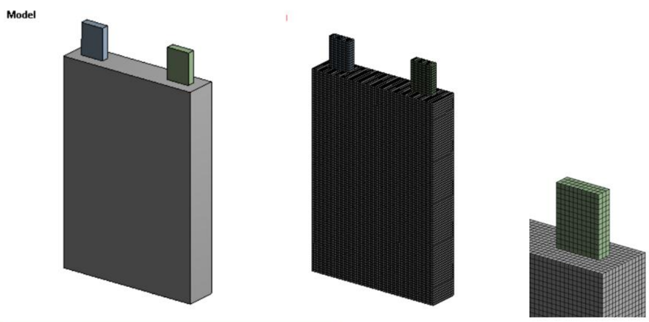


Figure 2: Assembly of child parts

3. 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:



Statistics	
Nodes	76384
Elements	68640

Figure 3: Battery cell meshing

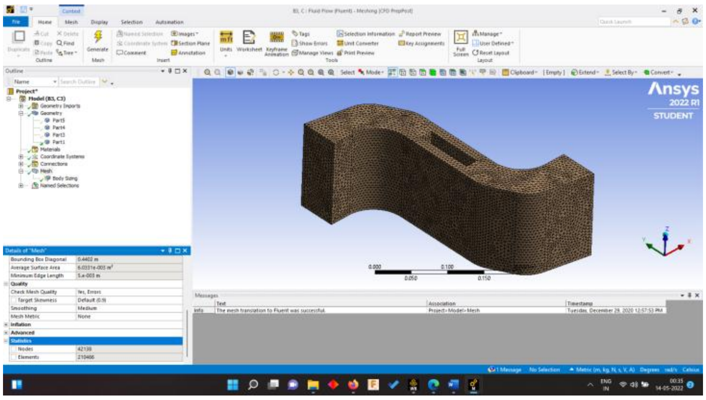


Figure 4: Fluid geometry meshing

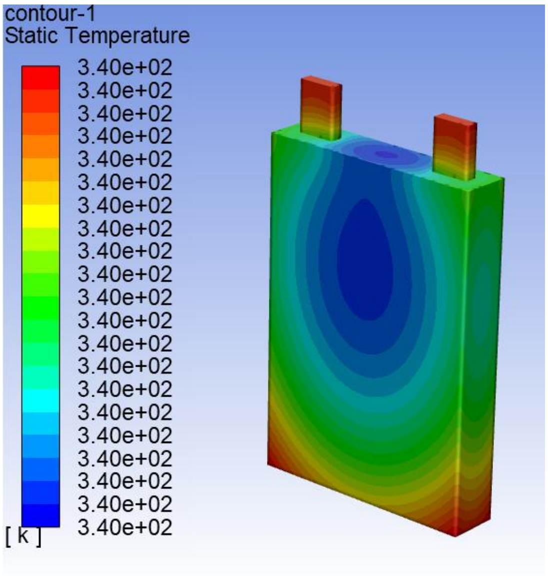


Figure 5: Battery cell static temperature results

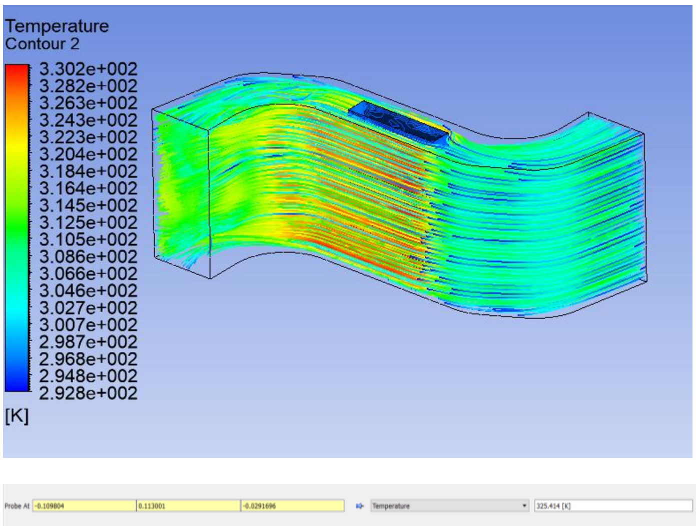


Figure 6: Battery cell temperature with air as cooling media

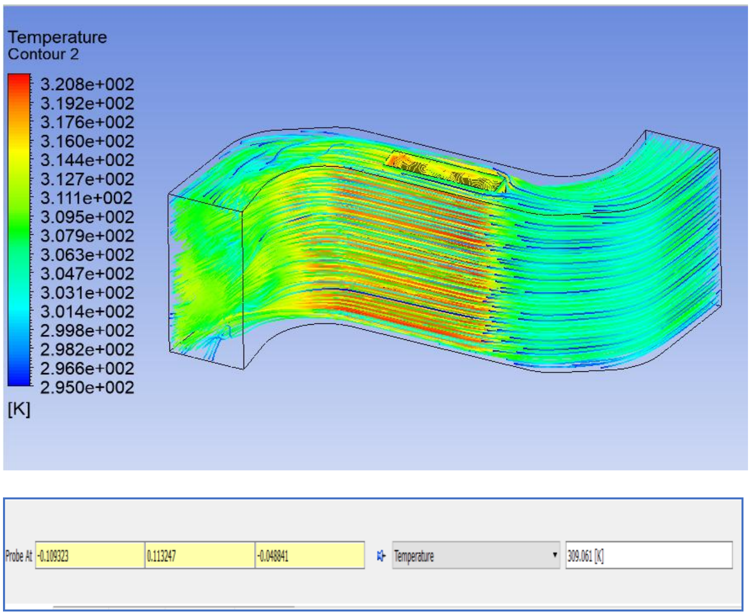


Figure 7: Battery cell temperature with Liquid cooling (Ethanol glycol) media

3. Results comparison

SR. NO.	PARTICULARS	TEMPERATURE in Kelvin	TEMPERATURE in °C	ΔT in °C
1	Battery cell temperature in static condition	340	66.85	
2	Battery cell temperature with air as cooling medium	325.4	52.25	14.6
3	Battery cell temperature with Liquid as cooling medium	309	35.85	35.85

From above results it is clear that the Battery cell cooling is more effective with liquid cooling medium compared to air cooling medium

4. CONCLUSIONS

- In static condition battery cell temperature along with terminals observed up to 340K which is 66.85°C.
- When fluid passed through the battery walls, the battery cell temperature dropped drastically.

- With air as a fluid media temperature of the battery cell dropped from 340K to 325.4K, which is 52.25°C. There is 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 the better thermal cooling of the battery cell, which ultimately results in better battery cell life, battery efficiency improves & battery can sustain for longer life.

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