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EV Battery Cooling using PCM and Force Convention Method

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Abstract: *The thermal battery management system (BTMS)'s goal is to preserve the health and effectiveness of the battery. as well as ensure that the temperature of the battery inside is in safe operating range. a conventional air cooling system not only does it need extra power, but it also can't meet. The demand for new lithium-ion battery (LIB) packs is high energy density, while liquid cooling requires BTMS complex devices to ensure the effect. Therefore, Phase change materials (PCMs) based on BTMS technology are now becoming commonplace. Using PCM s to Absorb heat, the temperature of the battery pack can be maintained Within the normal operating range for a long time without using any external force. It was an experimental platform developed to study thermal phenomena in a Li-ion battery With PCM material. CFD analysis will be performed to find out Battery EV temperature and PCM while operating state.*

Keywords: Battery, PCM, Temperature, CFD

I. INTRODUCTION

The reduction of CO2 in the atmosphere is one of the primary goals of the global energy transition. Currently, fossil fuels provide about 80% of the world's energy. The consumption of fossil fuels is among the highest in the transportation industry. The use of electric vehicles (EVs) powered by sustainable energy sources or hybrid vehicles can help to cut carbon emissions in the transportation sector by taking the place of internal combustion engines.

Li-ion batteries are typically regarded as the best option for EVs because of their high specific energy density, excellent stability, and low density. EV progress is absolutely reliant on Li-ion battery development. Li-ion batteries heat up during charge and discharge cycles, which seems to be the key factor affecting performance and a reduction in battery life. According to several case studies, high temperatures hasten the cathode electrode's breakdown, which lowers the battery's capacity. Therefore, the development of an effective Li-ion Batteries Thermal Management System (BTMS) becomes essential for ensuring improved performance, independence, and ideal longevity. Currently, there are three main categories for the BTMS: active systems, passive systems, and hybrid systems. Active cooling systems using air or liquid are the most popular among them. Even so, the low heat capacity and thermal conductivity of air systems places cooling restrictions on their use. In terms of energy use, expenditure, and upkeep, liquid systems are expensive. A cost-effective option is passive systems. Heat pipes and Phase Change Material (PCM) composites are the two main categories for passive systems. The battery pack produces a lot of heat while the car is running that needs to be released. 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 tested

II. OBJECTIVES

- To effectively reduce the temperature of EV batteries.
- The price of the cooling system utilised in electric vehicles should be decreased.
- The battery pack needs to be able to maintain the proper operating temperature with the help of cooling systems.
- Li-ion battery model with PCM and copper tube configuration subjected to thermal and CFD research.
- Creating an experimental testing setup based on CFD simulation and validating the CFD observations.

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III. METHODOLOGY

The methodology is carried out using the next procedure:
1. Find out literature survey, gathered research papers
2. Learnt about Battery Thermal Management System (BTMS)
3. Describe the literature gap, identify the need for a project
4. Finalizing the working Fluid (E.g., PCM or Nanofluids)
5. Finalizing concept 3D model and drafting will be done
6. CFD analysis of model

IV. LITERATURE SURVEY

A review of phase change materials used in heat management systems for electronic components, Li-ion batteries, and solar cells. Different types of thermal management systems are needed for solar cells, power batteries, and electronic components. On the other hand, PCMs with the correct phase transition temperatures can maintain those devices' temperatures within the desired range for an extended period of time.[1]

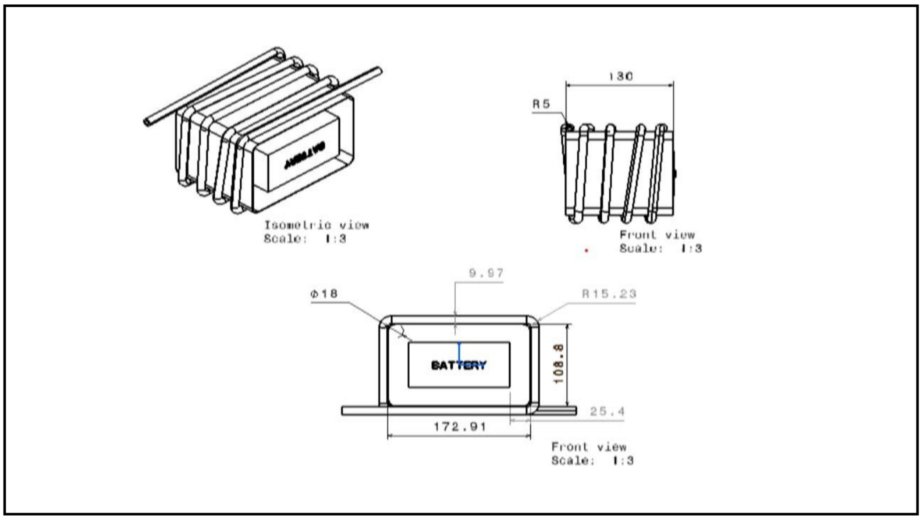
Using composite phase change materials, active cooling is used for battery thermal control. For lithium-ion batteries in electric vehicles, a thermal management system is necessary to regulate operational temperature and temperature changes. Phase change material (PCM) is frequently employed in the study of battery thermal management systems (BTMS). On the other hand, due to its low thermal conductivity, pure PCM is insufficient for transmitting the heat produced by battery cells. This issue was resolved by increasing PCM's heat conductivity using Cooper foam. The copper foam/paraffin composite phase change material (CPCM) was coupled with active liquid cooling to provide additional cooling. The copper foam is evenly spread with a coolant that is pumped via the cooling tube.The porosity of the copper foam is 98 percent, and the paraffin has a melting point of 25 °C.[2]

Using copper foam saturated with phase change materials, an experimental evaluation of a passive heat management system for three different types of batteries was conducted.[3]. Thermal Management System Using Phase Change Material for Lithium-ion Battery[4]

V. WORKING OF MODEL

Equipment designers and technical analysts can use CFD to simulate a virtual wind tunnel on their desktop computer due to its approach to modelling fluid flow phenomena. CFD is now recognised as a component of the computer- aided engineering, or CAE, spectrum of tools, which are widely used today in all industries.

5.1 Drafting



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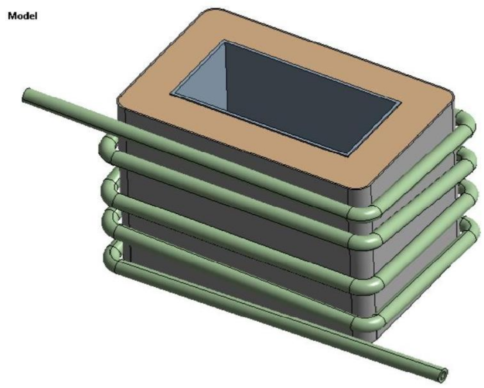
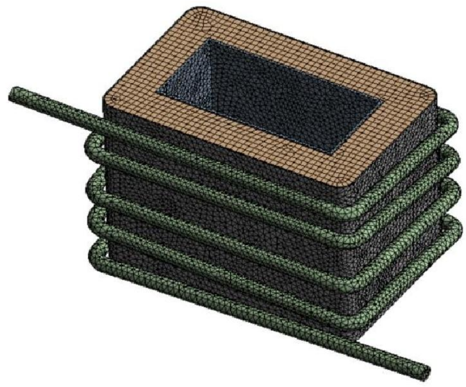
5.2 Geometry

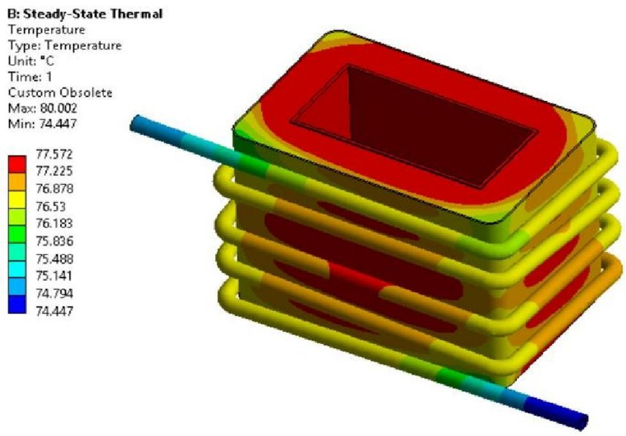


5.3 Meshing

Based on the type of analysis and the model's shape, ANSYS Meshing selects the best options. The ability of ANSYS Meshing to automatically utilise the available cores in the computer to perform parallel processing and so considerably shorten the time to produce a mesh is particularly convenient. There are no additional fees or licence requirements for parallel meshing.



5.4 Boundry condition and Result



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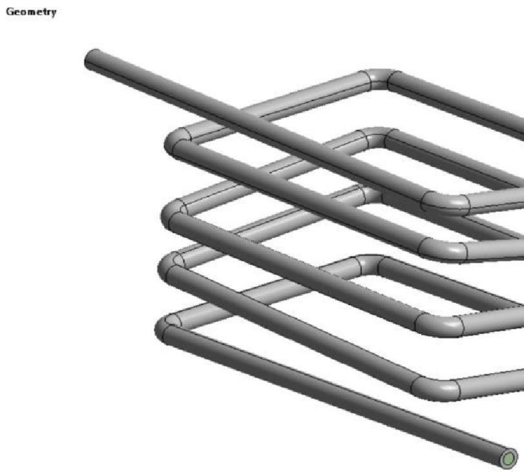
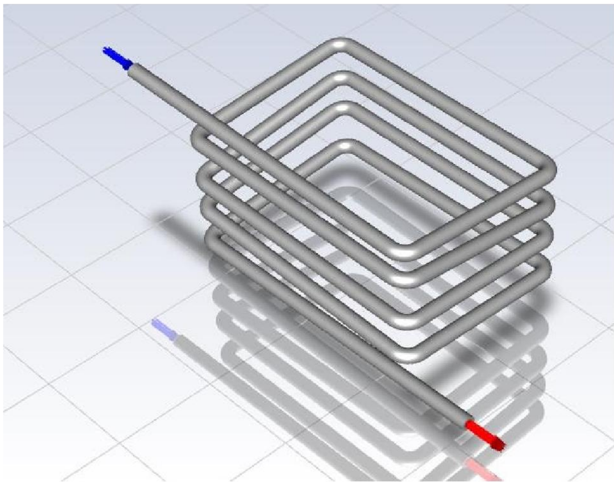
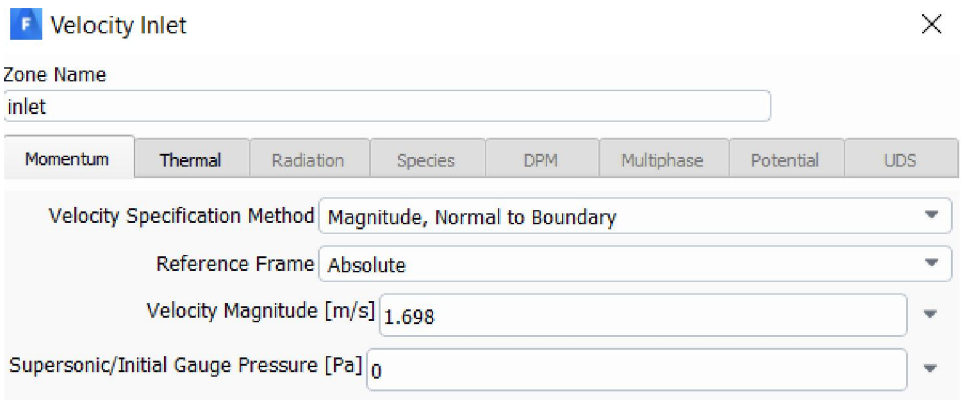
VI. CFD ANALYSIS OF WATER

6.1 Geometry



6.1 Boundary conditions





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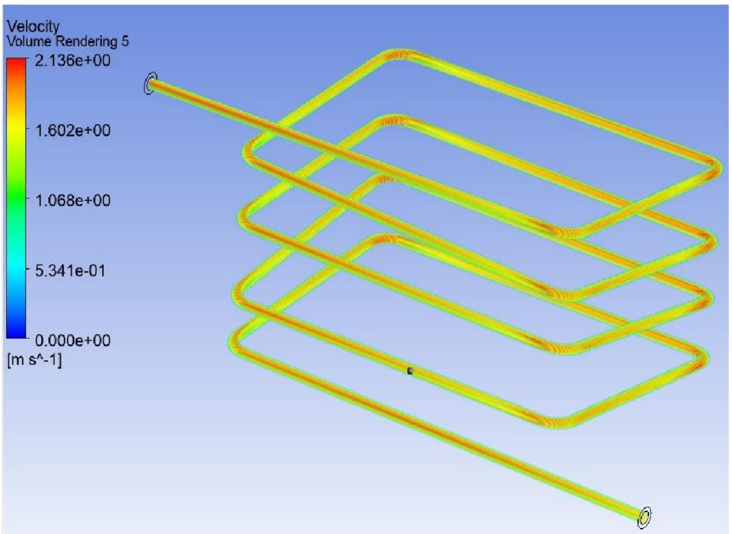
Calculation
v = Flow velocity
Q = Volumetric flow rate
A = Cross-sectional area

$$v = \frac{Q}{A}$$
$$Q = Volumetric\ flow\ rate = 120\ L/H$$
$$A = Cross\text{-}sectional\ area$$
$$A = \pi r^2$$
$$A = \pi \times 2.5^2$$
$$A = 19.63495$$
$$v = \frac{Q}{A}$$
$$v = \frac{120}{19.63495}$$
$$v = 1.69808117 \frac{m}{s}$$

VII. RESULTS - (FOR CONVENTIONAL)



Maximum velocity of water at outlet of pipe was 2.136 m/s

$\varphi = 2\%$	Al_2O_3-water	1.6525	0.001004	1056	3921	0.57
	CuO-water	1.5790	0.001142	1103	3700	0.54
	TiO_2-water	1.4937	0.001394	1060	3906	0.49
	Cu-water	1.4310	0.001690	1145	3629	0.44
	Ag-water	1.3725	0.001966	1187	3488	0.41
	Diamond-water	1.6482	0.001013	1047	3941	0.57

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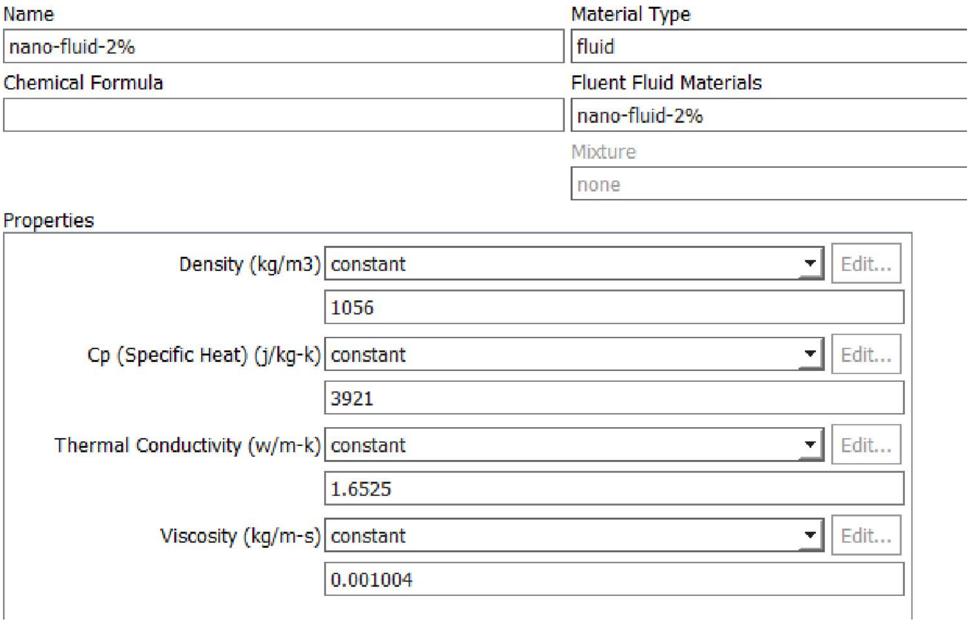
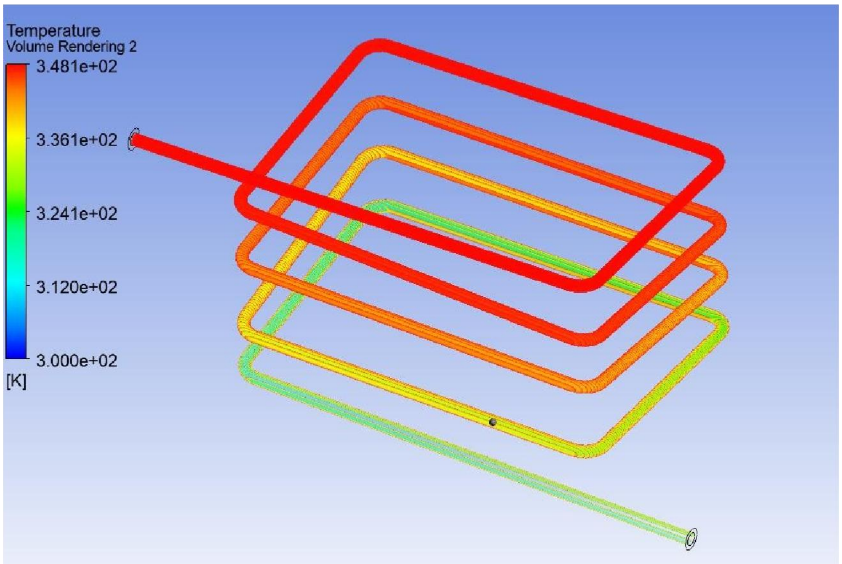


Results - Al_2O_3Nano fluid

Maximum Velocity of Al_2O_3Nano fluid at outlet of pipe was 2.160 m/s Maximum Temperature of Al_2O_3 Nano fluid at outlet of pipe was 348 K



Maximum Pressure of Al_2O_3 Nano fluid at outlet of pipe was 2.647e+04 Pa

Temperature of Al_2O_3Nano fluid at probe indicate on pipe was 342.571 K or 69.421 Degree Celsius

VIII. CONCLUSION

The phase change materials for battery temperature management of electric and hybrid vehicles are detailed in this presentation article. The difficulties and possible remedies for extending the battery life of EVs and HEVs through BTMS using PCMs are also discussed. Using the thorough description as a foundation, the following essential points and deductions have been made::

(a) Compared to traditional thermal management methods that use forced air convection or coolant, PCMs show to be a superior thermal management approach. The use of PCMs confirms uniform temperature distribution and lower maximum battery temperatures.
(b) PCMs have the potential to lower power usage and, in extreme cases, fail to maintain operational temperature. They do have drawbacks, too, like a reduced thermal conductivity.
(c) Multi-layer PCM-equipped structures can lower the price and mass of PCM cooling systems. A latent heat storage system's rate of heat transfer can be regulated by choosing PCMs with different phase change temperatures, thermal conductivities, and masses.

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