"CFD Modelling of Liquid Cold Plates for Efficient Thermal Performance of Electric Vehicle Li-ion Battery Modules"

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Abstract : **It has been estimated that the up to 2030 half of the market of vehicles will be of electric vehicles (EV). The performance of EV batteries has most important consideration in this revolution. Use of liquid cooled plates might be the option for improvement in performance of currently used most feasible Li-ion batteries. An effective modelling only can evaluates the thermal performance of immersion cooling for an EV Li-ion battery. Immersion cooling has an efficacy in enhancing maximum mobile temperature, cellular's temperature gradient, cell-to-cell temperature differential, and pressure drop within the module are investigated by direct assessment with a cold-plate-cooled battery module. Parametric analyses accomplished at specific module discharge c-prices and coolant drift costs to understand the sensitivity of every cooling method to important machine overall performance parameters. Parameters are modelled considering further requirement of numerical analysis using time-accurate Computational Fluid Dynamics (CFD). In this paper the model is proposed for further CFD analysis of liquid cold batteries. Indirect immersion cooling has higher thermal conductance provides lower cell temperature and lower temperature gradients at high discharge rates. Lower viscosity and density of dielectric liquid of an indirect cooled battery should performs considerably better.**

Keywords: ***CFD Modelling, EV Batteries, Electric Vehicles, Liquid cooling***

1. INTRODUCTION

The proliferation of electric vehicles (EVs) that outperform their internal combustion engine counterparts requires Li-ion battery packs that have high energy density, are able to maintain a high energy discharge, and are capable of fast charging, all while achieving high safety standards (5). Therefore, an efficient and optimized thermal management system (TMS) is critical to prevent cells from overheating, which in turn can lead to acceleration of battery cell deterioration (capacity fade and impedance rise), or an unsafe accident such as thermal runaway(). Also, a well-designed TMS is essential for the broader geographic adoption of electric vehicles, particularly in extremely hot or very cold climates, while maintaining cell temperature within the optimum range while the vehicle is in operation.(7)

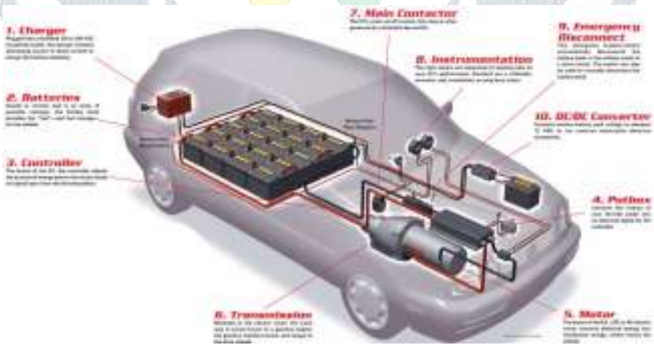

Fig.1: Schematic view of Battery Arrangement [1]

TMS strategies have been proposed to reduce the maximum cell temperatures in the battery module. These methods include convection air cooling, liquid cooling, two-phase vapor cooling using heat pipes, phase change materials (PCM) or a combination of these(8). Due to their high thermal conductivity, liquid cooling systems are known to be most effective in dissipating the high heat generated by the cells within the EV battery unit. Therefore, in this work, we focus our attention on an indirect liquid cooling system based on cold plates.(9)

Li-ion batteries consist of lithium at the positive electrode and an electrolyte where the lithium ions move from the positive electrode to the negative electrode during charging and vice versa during discharge(10). What gives lithium-ion batteries strength compared to other battery technologies is its volumetric and mass energy density(11). This feature makes lithium-ion batteries very attractive for various applications, particularly the automotive industry where energy density is critical. Lithium batteries are manufactured in three different shapes which are cylindrical, prismatic and bag. Figure 2. In cylindrical cells, the layers are rolled up and placed in a cylindrical case Figure 2. The advantage of this cell format is mechanical stability and ease of fabrication. Prismatic cell is packaged in packages to meet thinner design requirements. (12) They are mainly found in electronic devices such as cell phones. Bag cells feature the most efficient packaging by eliminating the metal casing and allowing for stacking.(13)

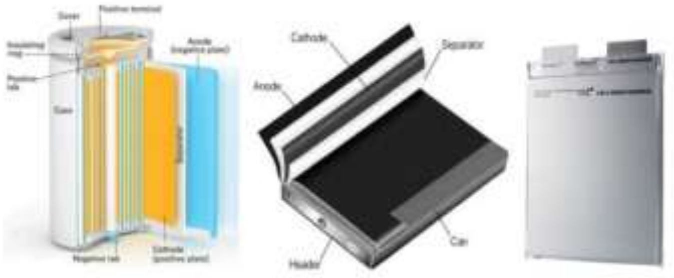

Fig.2: Lithium-ion cylindrical cell composition [2]

2. LITERATURE SURVEY

- Gautam Pulugundla, Prahit Dubey, and A Srouji, In the current study, we investigate the effect of a variety of plate channel size configurations on the overall performance of a liquid-cooled BM using three-dimensional, time-accurate, simulations with variable heat load from Li-ion cells. (1)
- E. Harikishan Reddy, In the present study, the thermal management of stacks in the power range of 1e10 kW is considered through computational fluid dynamics simulations. It is shown that large stacks need to have dedicated cooling plates through which a coolant is circulated. (2)
- Shashwat Bakhshi, Prahit Dubey*, AK Srouji, Zenan Wu, in order to keep the battery temperatures to be under the operational temperature limit, it is crucial that the selected cooling mechanism provides efficient transport of the heat generated by the battery modules and packs to the cooling media under all discharge and charge conditions.(3)
- Mohammad Rezwan Khan,. The presented focus applications are electrical vehicle and smart grid application. The efficiency parameter for battery cell is established using state of the art isothermal calorimeter by taking the consideration of heat related measurement. The calorimeter is principally used for the determination of the heat flux of the battery cell (4)

3. CFD MODELLING

To simplify the CFD simulation, the electrochemical reactions were not considered in the simulation. Cells are assumed to be constant heat sources. The amount of heat for each cell was estimated. Irreversible heat can be calculated using the internal resistance and current of the cell (irreversible = I2R). Reversible, blendable and phase change heat is estimated to be 20% of reversible heat. The C rate is a relative measure of battery performance. For one C rate means the cell is operating at its rated capacity, for a C rate of 0.5 means half the rated capacity and so on.

To carry out an evaluation of different BTMS methods, each cooling technique has been studied the use of star--CCM+ software. models of li-ion battery and the battery modules were made for every cooling method.

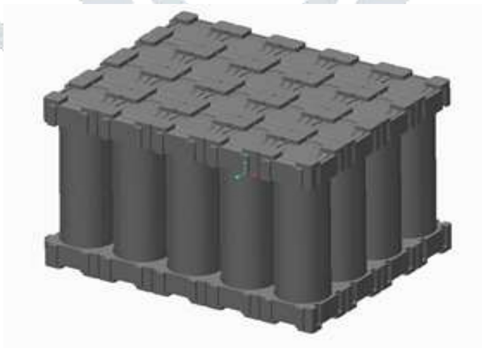

Fig.3.Cad Assembly of Battery

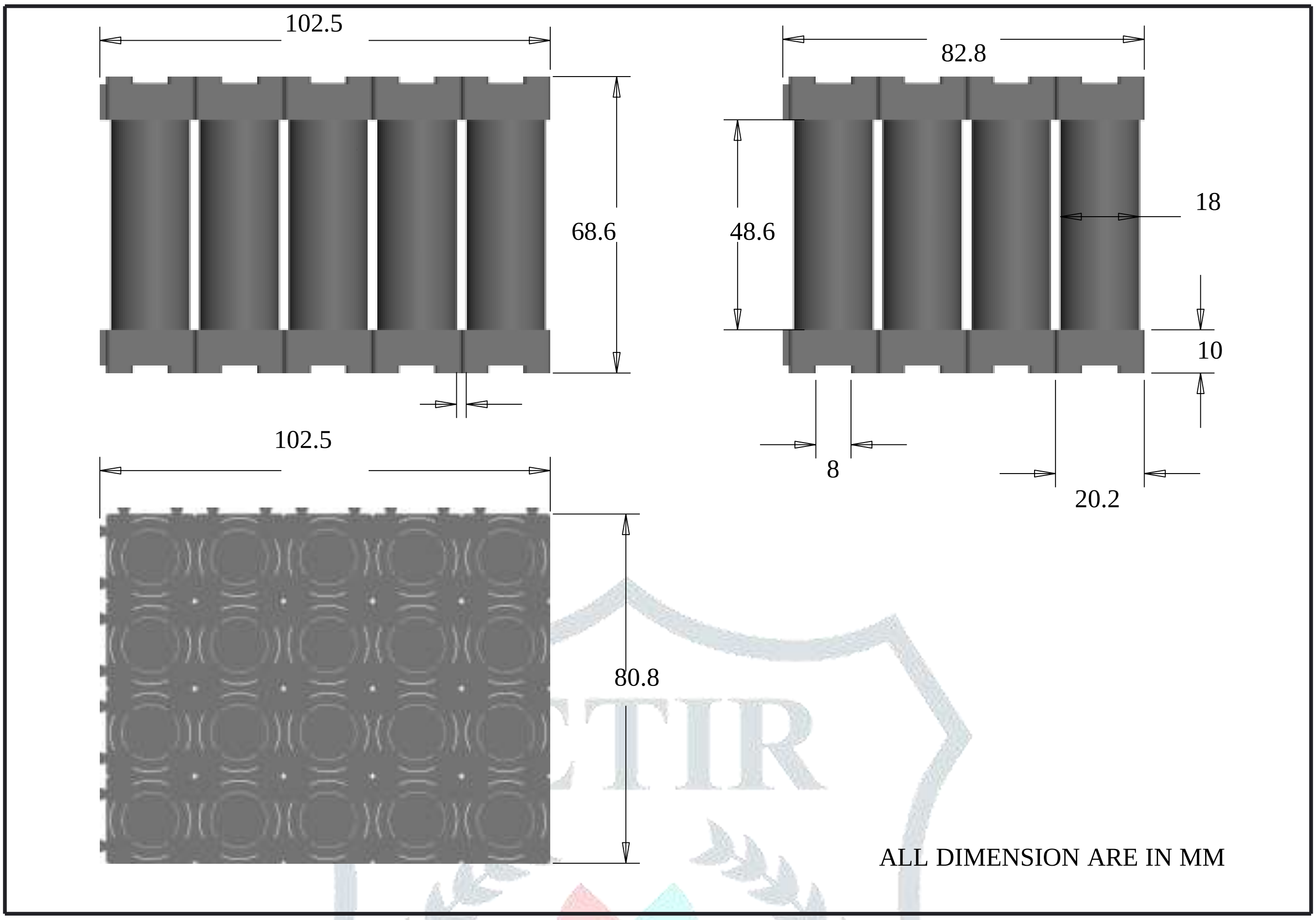

Fig.4.Cad Assembly of Battery (with dimension)

4. BOUNDARY CONDITIONS

All of the simulations are executed in the constant country, as the intention has been to compare the overall performance of different cooling answers. The consequences from the simulations are studied based on sure elements, namely maximum temperature, temperature distribution, maximum heat in keeping with mobile, parasitic strength. In addition to these a few qualitative elements which include thermal runaway safe t y is likewise mentioned

Maximum temperature: temperature of a cellular is a critical element both for its' overall performance and safety. The most allowable cell temperature is 35oc. This cost is recommended to have the fine lifespan for cells.

Temperature distribution: It has an instantaneous effect at the performance of the cell. The maximum allowed temperature distinction allowed between two cells and within a cell is 5oc.

Minimum coolant required: The temperature difference in a module is without delay dependent on the quantity of coolant used. For every of the models, the minimum coolant had to keep the temperature difference among cells 5 levels is measured.

The images shown the cell composition of the same geometry in each application.

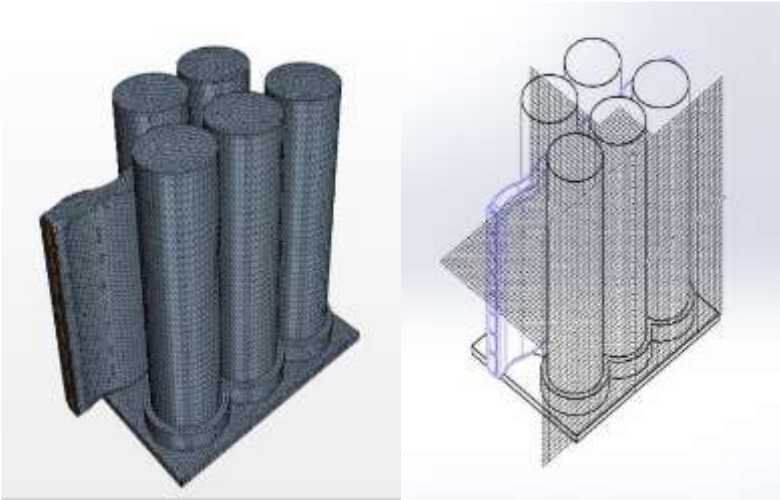

Fig .5 : Meshing/Discretization of Geometry used

5.CONCLUSION:

This Study illustrates the most commonly used battery thermal management systems. One of the principal contributions of this work is to provide a radical assessment of the cooling methods particular to 21700 lithium-ion cells based totally on CFD simulations and industrial use cases. 4 particular cooling techniques have been simulated with the CFD software. Using boundary conditions like maximum temperature, temperature distribution and Minimum coolant required. To simplify the CFD simulation modelling . by using this result with CFD anyalsis performance of battery can be calculated.

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