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"THERMAL ANALYSIS ON COOLING PLATE FOR BATTERY MODULE OF AN EV VEHICLE BY COMPUTATIONAL TESTING"

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ABSTRACT

The performance of lithium-ion batteries used in electric vehicles (EVs) is greatly affected by temperature. Hence, an efficient battery thermal management system (BTMS) is needed to ensure the safety of batteries and prolong the cycle life. In order to find a more efficient type of cooling plate for the rectangular batteries, the three-dimensional models of four common cooling plates with different internal structures are established. After a series of computational fluid dynamic simulations and comparisons, the most optimum structure of the cooling plate is obtained. Subsequently, the effect of different mass flow rates is investigated among the different cooling plates.

Key Words: *lithium-ion batteries, BTMS, EVs, CFD*

I. INTRODUCTION

With the rapid development of electric vehicles (EVs), the technical requirements of lithium-ion batteries are constantly increasing (Ren 2018). How to ensure the long-term and efficient operation of EVs has become a hot spot for many researchers. In order to meet the needs of users for the endurance of EVs, battery technology is constantly developing, and the energy density of batteries is also increasing (Yuksel et al. 2016). Accordingly, the requirements for a battery thermal management system (BTMS) should also increase (Wang et al. 2016). At very high or low temperatures, the capacity of a lithium-ion battery decreases greatly with increasing cycle times. Ramadass et al. (2002) studied the capacity of batteries under different charging and discharging cycle times. The research showed that with the increase of batteries' surface temperature, the number of charge or discharge cycles of batteries decreased a lot, and the batteries would aging more with the wide range of temperature fluctuations. A lithium-ion battery often exceeds its optimal operating temperature range because of the complex road conditions, ambient environment, and driving habits of automobiles (Guo and Chen 2015). The C-rate is the charge or discharge current divided by battery capacity. The rate 1C means that fully charging or discharging a battery requires 1 h, while 2C means only 0.5 h is needed to complete it. It not only has a negative impact on battery endurance, but a long time at a high temperature is more likely to threaten our personal safety. For example, Flight JA829 was reported to be on fire and smoking in 2013 because of the battery thermal management out of control. In recent years, reports of electric vehicle fire due to excessive battery temperature have also been common occurrences. This has also aroused widespread concern about the safety of electric vehicles

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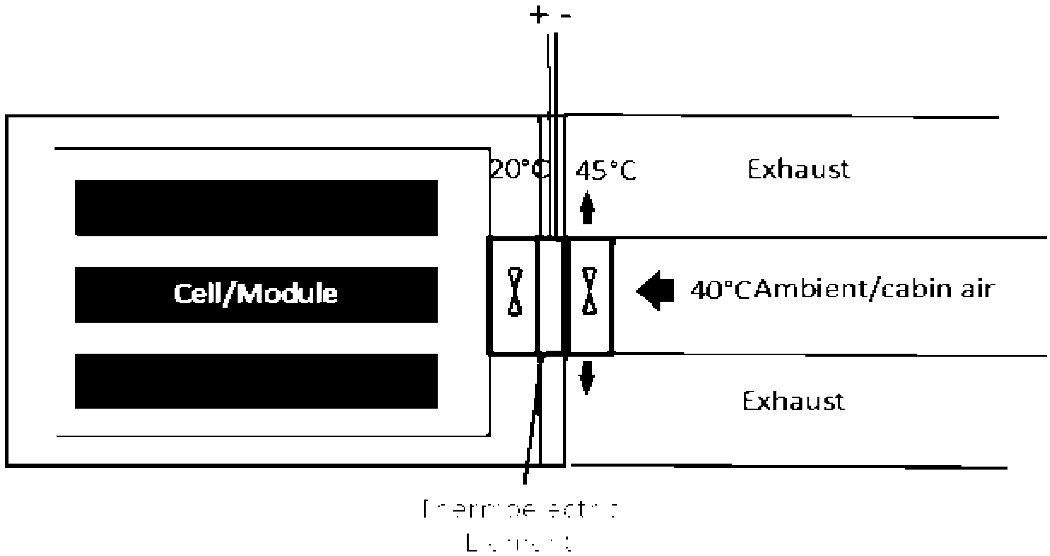

Fig 1.1 Thermoelecrtric cooling / heating system

II. RESEARCH METHODOLOGY

With everything taken into account, there are two central fragments that were performed at this moment. The essential fragment is to develop a 3-layered model of the grip circle, followed by performing restricted part examination using business limited part (FE) programming to consider the warm furthest reaches of the business grasp plate as showed up in figure under.

Methodology

Stage 1: Aggregation data and information connected with cooling balances of IC motors.
Stage 2: an absolutely parametric model of the motor square with balance is made in ANSYS programming system bundle.
Stage 3: Model got in Step an attempt of is examined utilizing ANSYS 19 (Workbench), to get the hotness or hotness rate, warm inclination and nodal temperatures.
Stage 4: Manual computations are finished.
Stage 5: Finally, we will generally will more often than not check the outcomes acquired from ANSYS and manual calculations for totally unique material, shapes and thickness

III. FINITE ELEMENT ANALYSIS & MATERIAL PROPERTIES

The restricted part technique is mathematical examination framework for finding unpleasant solutions for a wide combination of planning issues. Because of its various assortment and flexibility as an examination gadget, it is tolerating a great deal of thought in essentially every industry. In progressively planning conditions today, observe that it is essential to gain unpleasant solutions for issue rather than exact shut find course of action. It is incomprehensible to hope to find insightful mathematical solutions for some, building issues. An intelligent courses of action is a mathematical explanation that gives the assessments of the best dark sum at any region in the body, as result it is real for ceaseless number of region in the body. For issues including complex material properties and cutoff conditions, the planner resorts to mathematical procedures that give induced, yet commendable courses of action. The restricted part procedure has turned into an indispensable resource for the mathematical courses of action of a wide extent of building issues. It has been developed meanwhile with the extending use of the fast electronic automated PCs and with the creating complement on mathematical procedures for planning examination. This methodology started as a hypothesis of the helper plan to specific issues of adaptable continuum issue, started with

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respect to different circumstances.All the above frameworks have been coordinated with usage of a predefined conditions and prerequisites that helps with obtain the suitable and trustworthy result.

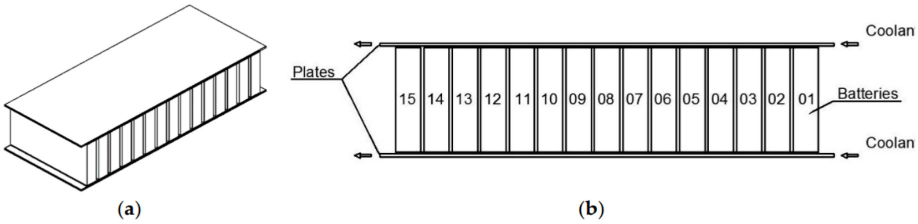

Fig. 3.1 Simplification of 2D battery model

Table 3.1 The properties and value used in the analysis

Size of battery cell	11×248×260 mm^3
Size of aluminum cooling plate	t×248×260 mm^3
The type of Al plate	Al-1100
The temperature of coolarnt	25°C
Heat capacity of battery cell	880 J/kg·K
Heat conductivity of battery cell	4 W/m·K
Heat transfer coefficient (b/w Al plate battery)	1000 W/ m^2·°C
Thermal dissipation of the battery	12 W (Average value)

IV. MODELING & SIMULATION

4.1 Modeling of cooling plate

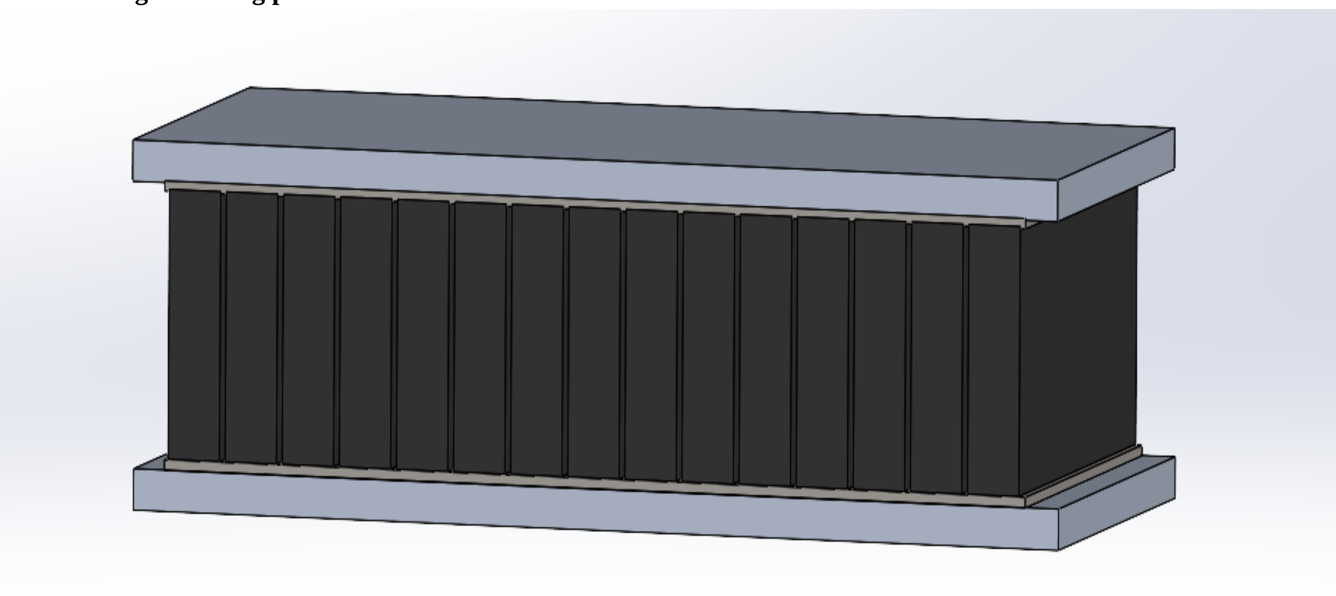

Fig.4.1 3D model of cooling plate with 15 Lead battery set box

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4.2 AL 92 material

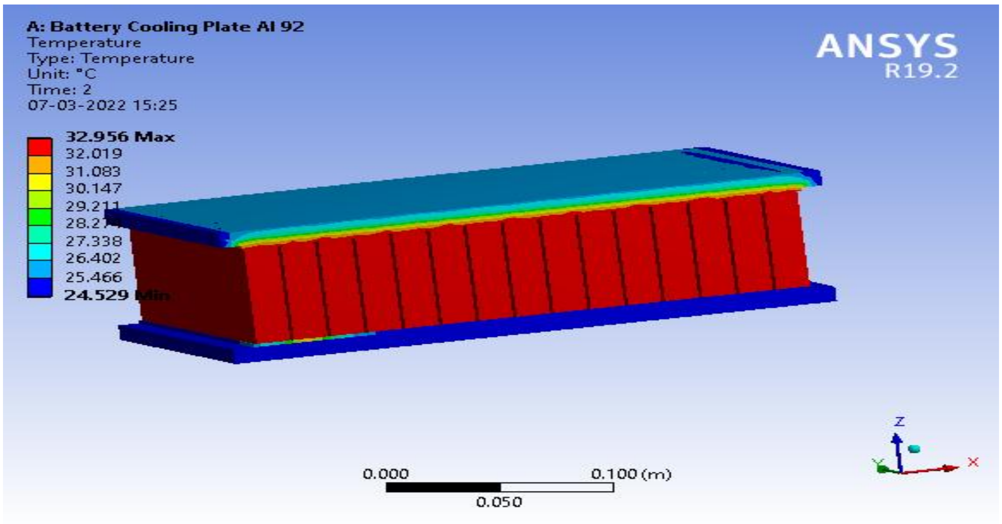

Fig 4.2 AL 92 Alloy material cooling plate temperature results

4.3 AL 96 Alloy material

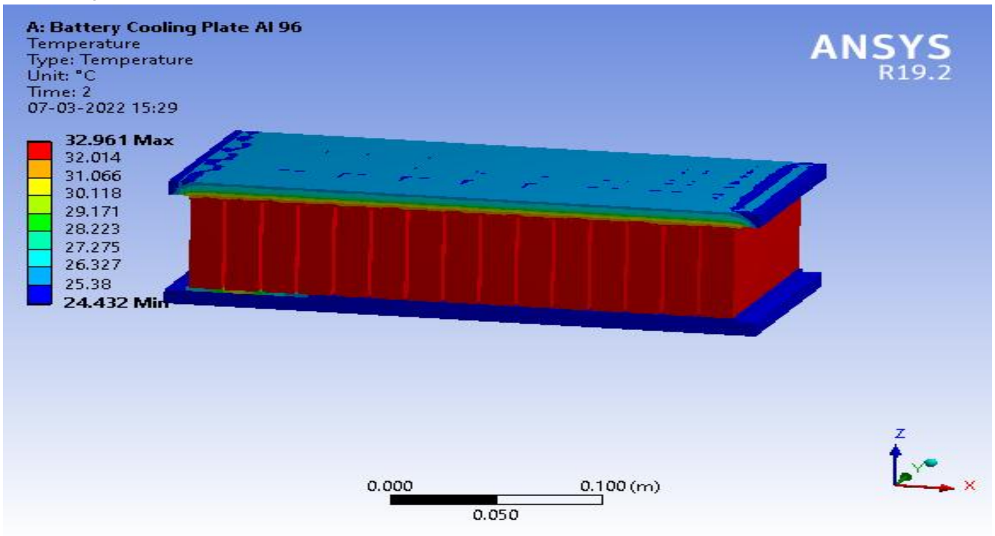

Fig.4.3 AL 96 Alloy material cooling plate temperature results

4.4 Al 1100 Alloy

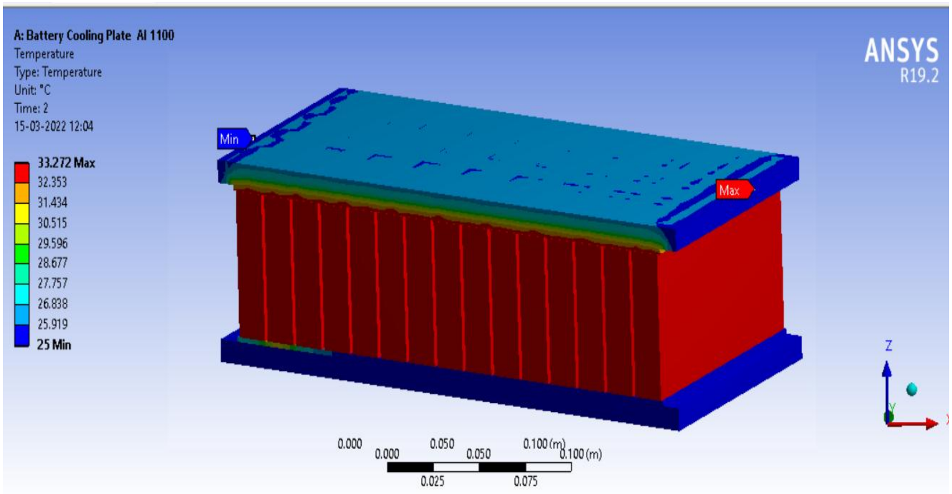

Fig.4.4 AL 1100 Alloy material cooling plate temperature results

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V. CONCLUSION

The liquid cooling has been increasingly used instead of other cooling methods, such as air cooling and phase change material cooling. In this article, a lithium iron phosphate battery was used to design a standard module including two cooling plates. A single battery numerical model was first created and verified as the basis of the module heat transfer model. Orthogonal experimental design method was adopted in the module thermal model to optimize the main parameters in the module: Battery gap, the cross-section size, and the number of coolant channels of the cooling plate. The Surrogate Model was then utilized to further optimize geometry of the cooling plate. Finally, the optimized geometry was rebuilt in the module thermal model for analysis. The comparison showed that the maximum and minimum temperature difference in the cooling plate was reduced by 9.5% and the pressure drop was reduced by 16.88%. It was found that the battery temperature difference and the pressure drop decreased with the increase of the cross-section and number of the coolant channel when the coolant flow rate was constant at the inlet.

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