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Modelling and Analysis of Lithium-IoN Battery Pack

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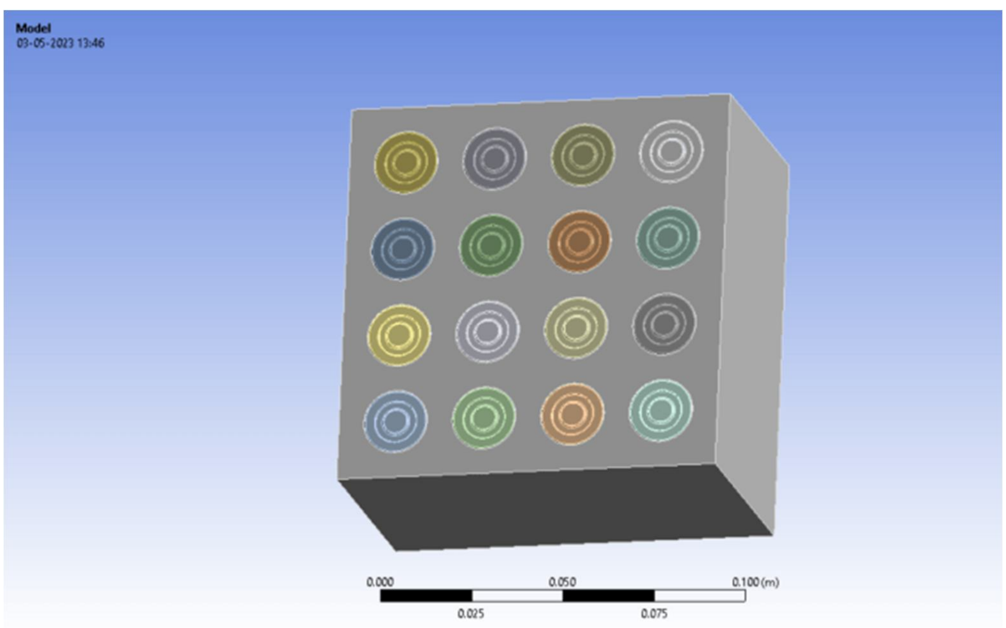
Abatract: As one of the most widely used energy storage technologies, lithium-ion batteries (LIB) play a significant role in modern society. The effectiveness of LIB is significantly impacted by thermal management. Phase change material (PCM)-based phase change cooling has emerged as a promising approach since it has a large latent heat and doesn't require additional pump power. In this study, phase change cooling with PCM has been used to numerically and experimentally analyse the thermal performance of a battery module containing 25 parallel 18650 lithium-ion batteries. First, in order to construct the heat generation model, the internal resistance of the unit cell has been experimentally tested. The impacts of PCM's thermophysical properties, such as thermal conductivity, are based on the heat generation model and the heat transmission model.

I. INTRODUCTION

Electric vehicles are currently widely developed in the markets as one of the most promising technologies replacing the internal combustion engine in the transportation sectors. Due to its high energy storage density, lengthy cycle life, and low self-discharge, lithium-ion batteries (LIB) are one of the most crucial power sources for electric cars. Due to the limited working temperature range required to achieve high charging-discharging efficiency, LIB performance is temperature-dependent. After prolonged use, LIB is resistant to producing additional heat in the working process. The extreme temperature changes of the LIB throughout the charging and discharging process could lead to a major fire safety concern. power could put strain on the batteries in vehicles because of their capacity limitations. Due to its superior performance in temperature control, straightforward design, and lack of additional power consumption, thermal management of LIB based on phase change cooling using phase change material (PCM) has gained attention in recent years PCM for LIB thermal management .The maximum temperature of the LIB pack employing phase change cooling is 8 C lower than that of natural air cooling, according to the results. created a composite PCM augmented with graphene for the thermal control of LIB, taking into account paraffin's poor heat conductivity.

II. EXPERIMENTAL TEST



RO = a1 ∗ T 4 + a2 ∗ T 3 ∗ SOC + a3 ∗ T 2 ∗ SOC 2

$+a4 * T * SOC\ 3 + a5 * SOC\ 4$
$+a6 * T\ 3 + a7 * T\ 2 * SOC + a8 * T * SOC\ 2$
$+a9 * SOC\ 3 + a10 * T\ 2 + a11 * T$
$*SOC + a12 * SOC\ 2 + a13 * T + a14 * SOC + a15$
$Rp = b1 * T\ 4 + b2 * T\ 3 * SOC + b3 * T\ 2 * SOC\ 2 + b4$
$* T * SOC\ 3 + b5 * SOC\ 4 + b6 * T\ 3 + b7 * T\ 2 * SOC + b8$
$* T * SOC\ 2 + b9 * SOC\ 3 + b10 * T\ 2 + b11 * T * SOC + b12$
$* SOC\ 2 + b13 * T + b14 * SOC + b15$

III. PREPARATION AND TEST OF COMPOSITE PCM

The composite PCM of paraffin and expanded aluminium is created with consideration for the low thermal conductivity of pure paraffin in order to increase its thermal conductivity. displays images of enlarged aluminium and paraffin. The preparation procedure is depicted.

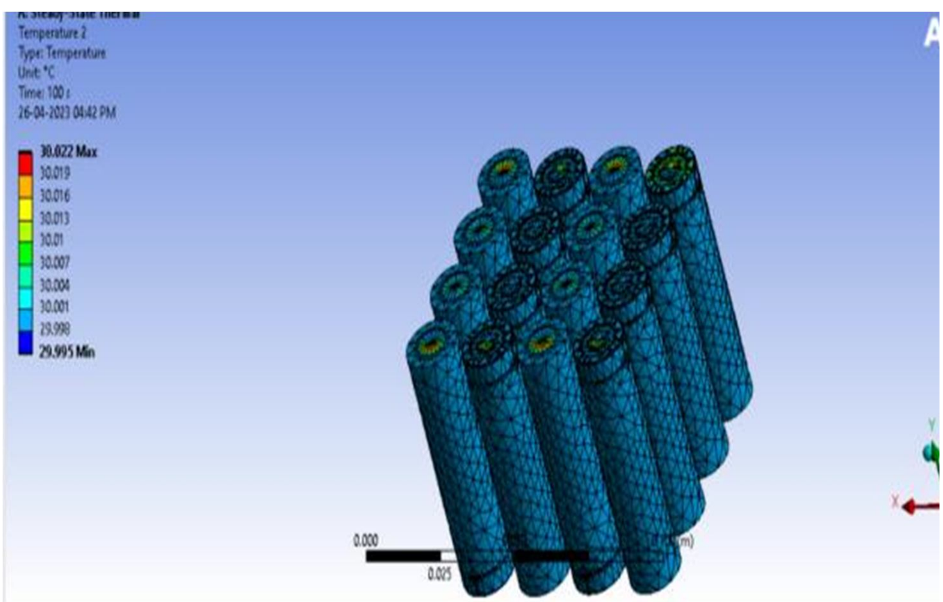
The thermophysical parameters for the subsequent numerical simulation should be tested after the composite PCM has been prepared. The thermophysical characteristics of pure paraffin and composite PCM, such as thermal conductivity, specific heat capacity, latent heat, and melting temperature, are carefully investigated using the differential scanning calorimetry (DSC) technique and other tools like the LFA. depicts the DSC curve for composite PCM, and lists the specific parameters.

IV. RESULT AND DISCUSSION

This study's primary objective is to assess how PCM thermos-physical factors affect LIB's thermal management performance. First, considering the low heat conductivity of pure paraffin, the thermal management performance of paraffin and extended aluminium is compared. both under standard operating circumstances and under stress. The impacts of thermal conductivity are then thoroughly examined in order to choose prospective PCM for future studies more effectively. Later, additional variables like the paraffin's latent heat of fusion and the porosity of the composite PCM

V. EFFECTS OF THERMAL CONDUCTIVITY

Thermal conductivity has been shown to have a significant impact on the effectiveness of thermal LIB control when using PCM cooling. Further research is necessary to determine how large PCM's thermal conductivity should be. Expanded graphene can also increase the thermal conductivity of composite PCM while lowering density and latent heat. The impacts of thermal conductivity on the LIB thermal management performance are therefore examined in this part in order to determine the ideal range of thermal conductivity. In the simulation, a few fictitious PCMs with various thermal conductivities are examined in both the unstressed and stressed states.



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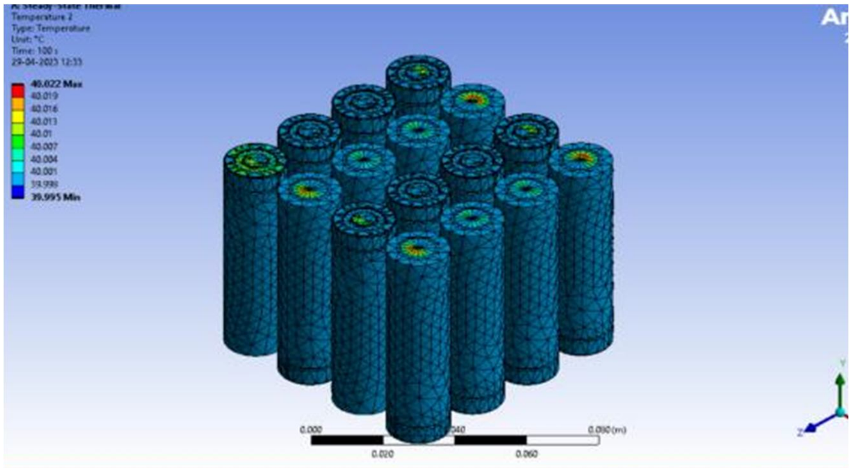
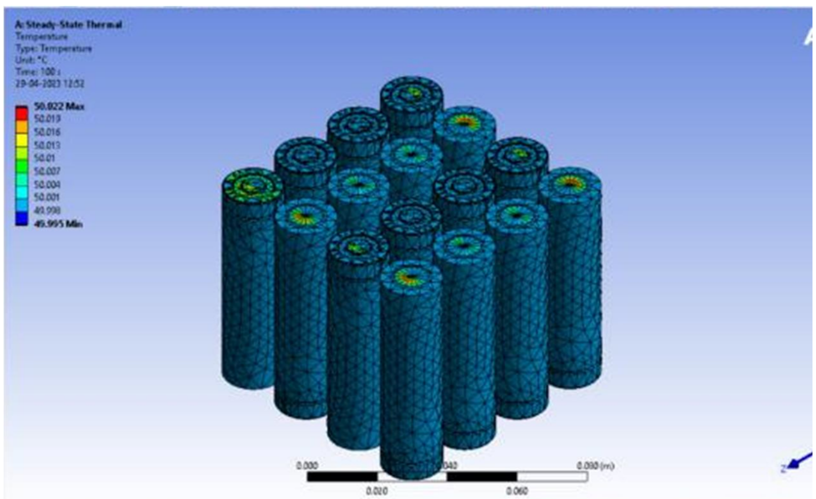
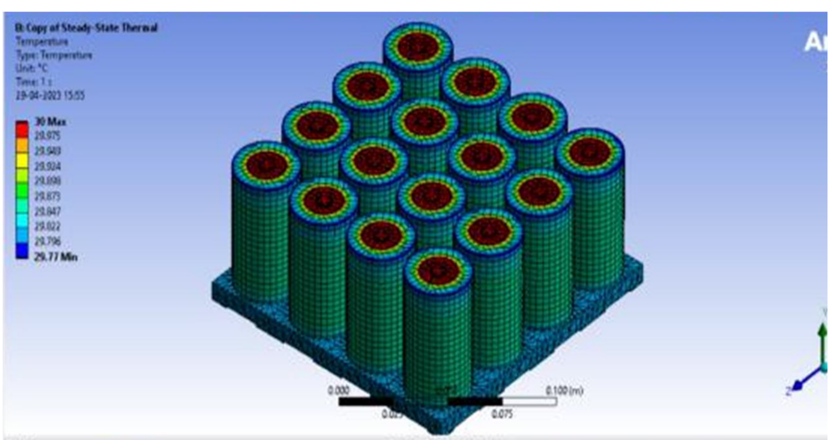
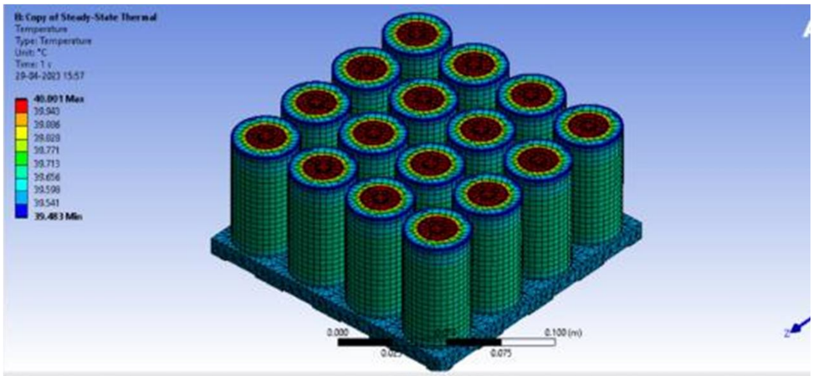


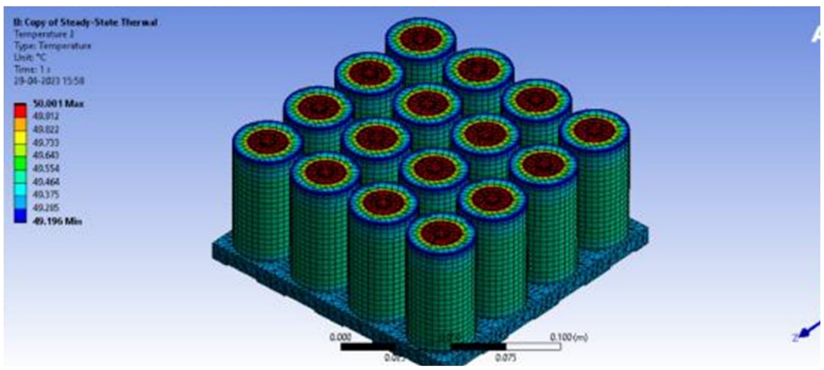


VI. EFFECTS OF LATENT HEAT OF PCM

Latent heat of PCM is an important parameter to affect the LIB thermal management performance. In order to investigate the effects of latent heat and find optimal latent heat of PCM, the thermal management performance of some hypothetical PCMs with different latent heat are analysed. The latent heat changes from a constant difference . All the hypothetical PCMs has a thermal conductivity of the maximum temperature and temperature difference of LIB cooled by PCMs with different latent heat under normal condition and stressed condition. It can be seen that the maximum temperature of LIB keeps decreasing with the increase of latent heat in both the normal condition and stressed condition.







VII. CONCLUSION

Due to a knowledge gap, the effects of PCMs' thermophysical characteristics are thoroughly examined in this study. In order to choose viable PCMs for future practical applications and learn how these characteristics affect LIB thermal management performance using PCM cooling. Some inferences are made based on the experimental test and simulation study as follows:

1) Because paraffin/EG has a high thermal conductivity and can easily transfer heat from the LIBs to the surrounding PCM and from the centre to the outer PCM, it performs better thermal management than pure paraffin for LIB packs in both normal and stressed conditions. As a result, the maximum temperature is lowered and the temperature field is more uniform.
2) Results indicate that, particularly under pressured conditions, the bigger latent heat achieves smaller maximum temperature and temperature difference for LIB pack. Due to the fact that more latent heat always equates to lesser thermal conductivity, the latent heat is not as great as it may be in practical applications. The constructed LIB pack in this investigation has the best latent heat when the effectiveness of temperature control is taken into account.
3) Due to its extremely high thermal conductivity, foam can be used to regulate the temperature difference of LIB packs at any porosity; nevertheless, the maximum temperature of LIB packs first drops quickly before gradually rising as the porosity of metal foam increases. In order to provide the greatest thermal management performance, taking into account both the maximum temperature and the temperature difference of the LIB pack, the optimal porosity exists.

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