Lithium ion battery thermal safety and prevention measures

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Introduction: Lithium ion battery(LIB) safety problem has attracted the whole world's attention especially after the explosion of Samsung Galaxy Note 7. This work mainly deals with the study of gestation conditions, occurrence characteristics and prevention measures of the battery fire, including the heat generation, thermal abuse model and battery thermal management system.

Figure 1. Thermal runaway caused fire of lithium ion batteries.

Method: A thermal abuse model was proposed to predict the thermal runaway of battery, which coupled the 1D electrochemical model and 3D thermal model, especially considering the material decomposition heat(Q_{ex}).

$$\rho C_P \partial T/\partial t = \vec{\nabla}\left(K_{T,j}\vec{\nabla}T\right) + Q_g + Q_{ex}$$

$$Q_g = Q_{rxn} + Q_{rev} + Q_h$$

$$\rho Vc\frac{dT}{dt} = I(E_q + Tz) + \Delta H' M' A' \exp(-\frac{E_a'}{RT}) - \pi DLh(T - T_{sur}) - \varepsilon\sigma\pi DL(T^4 - T_{sur}^4)$$

In addition, a composite board based battery thermal management system(BTMS) was put forward in this work, which contains a heat conducting shell, an insulation panel and phase change material (PCM).

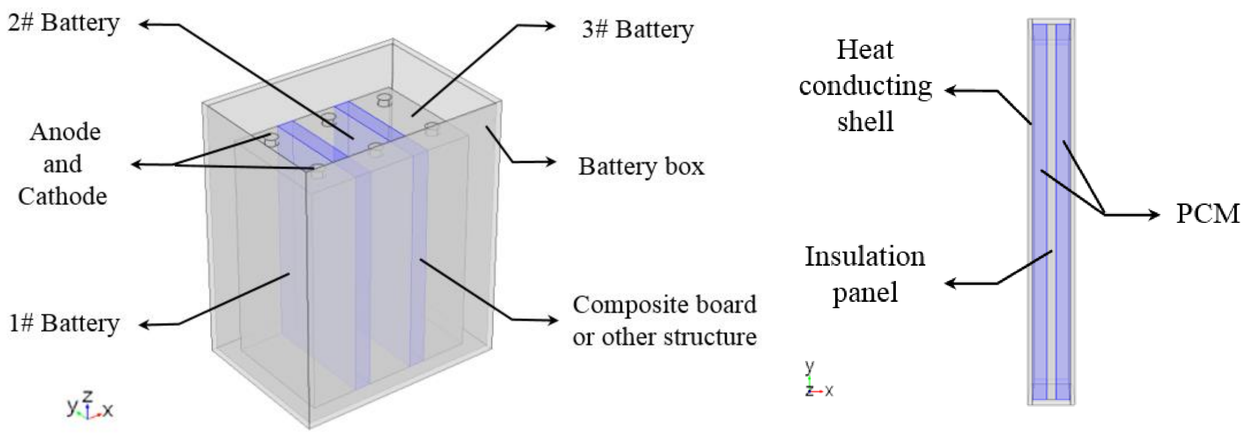

Figure 2. The schematic of the Li-ion battery thermal management system.

Results: This work reveals the heat generation of LIB during the dynamic cycling and predicts the thermal runaway of battery. Furthermore, the proposed BTMS can effectively improve the heat dissipation capability and the heat-insulation capability of the battery pack.

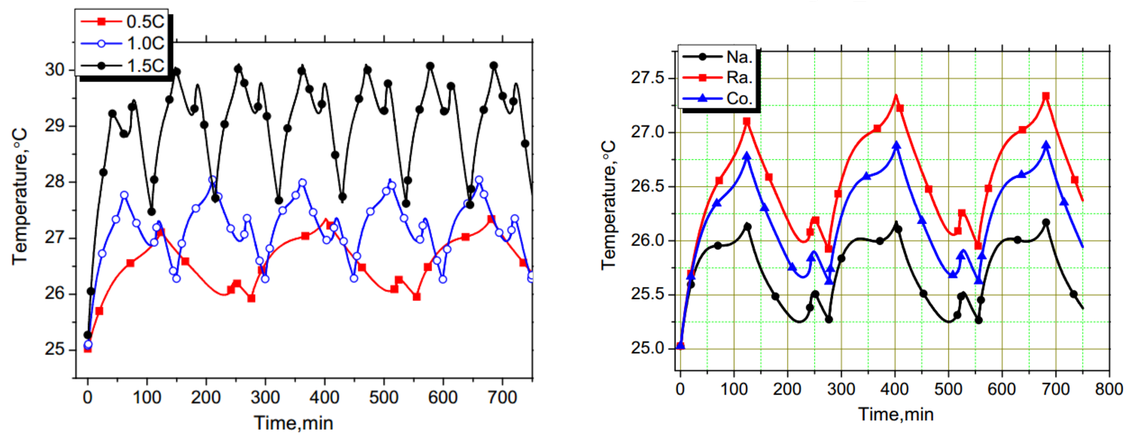

Figure 3. The comparison of temperatures under the natural cooling condition with different current rates.

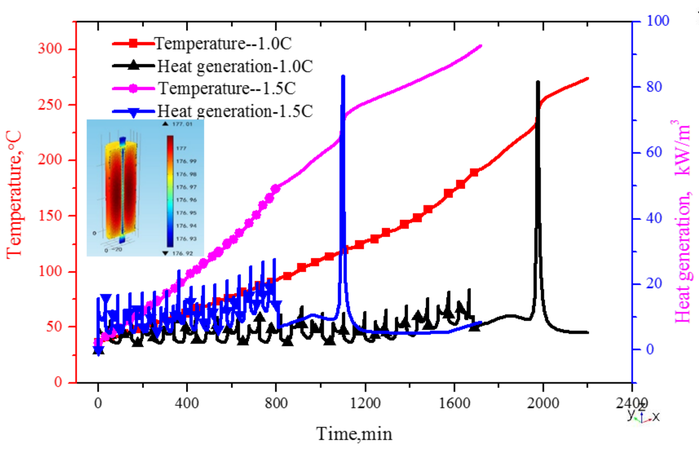

Figure 4. Thermal runaway of 50Ah lithium titanate battery.

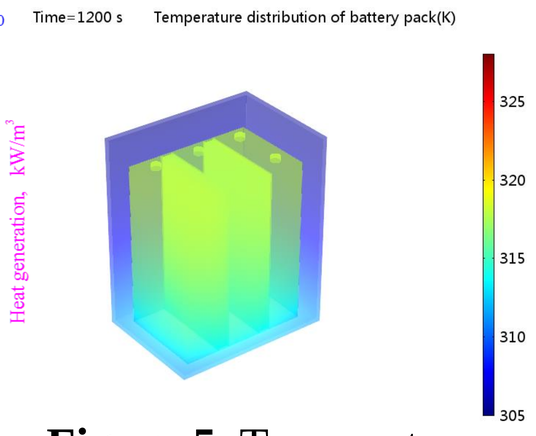

Figure 5. Temperature distribution of BTMS at the end of 3 C discharge.

Conclusion: The simulation results of heat generation of LIB agree well with the experimental data. The thermal abuse model coupled with the material decomposition heat can be used to predict the thermal runaway of LIB. The proposed BTMS will be further studied in the future.

References:

1. Qingsong Wang, et al. Heat Transfer in the Dynamic Cycling of Lithium-titanate Batteries, International Journal of Heat and Mass Transfer, 93 (2016) 896–905.
2. Qiujuan Sun, et al. Numerical study on lithium titanate battery thermal response under adiabatic condition, Energy Conversion and Management, 92 (2015) 184–193.
3. Man Chen, et al. A thermal runaway simulation on lithium titanate battery and the battery pack, Energies, 8 (2015) 490–500.
4. Jiajia Yan, et al. Numerical study on the thermal performance of a composite board in battery thermal management system. Applied Thermal Engineering, 106 (2016) 131–140.