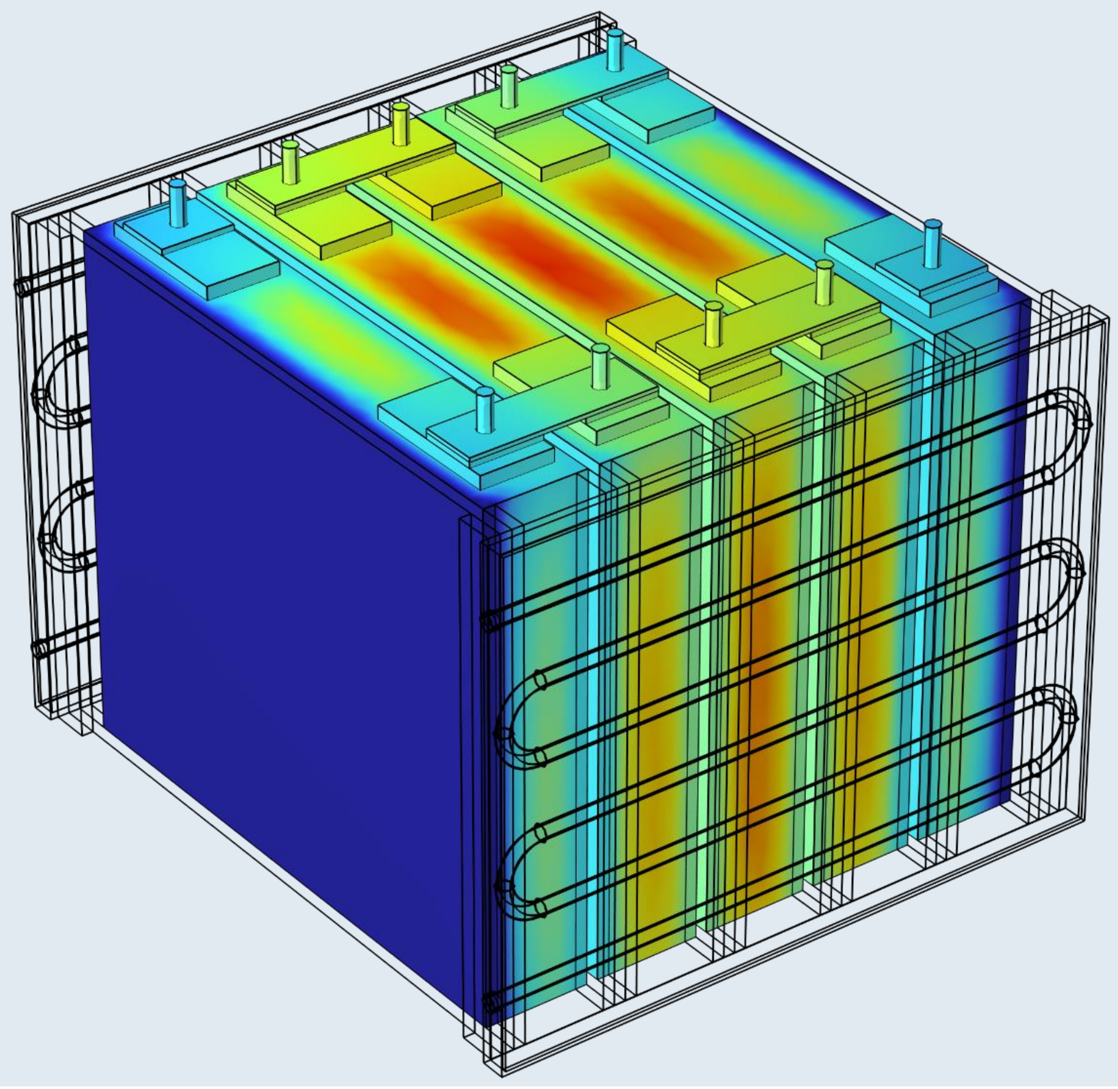

Thermal management performance and optimization of a novel system combining heat pipe and composite fin for prismatic lithium-ion batteries

A novel passive thermal management system improves the temperature performance of the battery module, and the optimized active and passive system shows advantages in overall performance

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Abstract

A battery thermal management system (BTMS) with excellent comprehensive performance is vital to the safety of the battery module. This study proposed a novel BTMS that utilized the heat pipe coupling composite fin (HPCF). The HPCF displayed superior thermal performance to other comparison systems.

A novel comprehensive criterion, thermogravimetric coefficient (TGC), was developed to assist in optimizing the structure of passive BTMS. At extreme conditions, an optional liquid cooling strategy of the controllable ambient temperature range at a certain flow velocity was proposed.

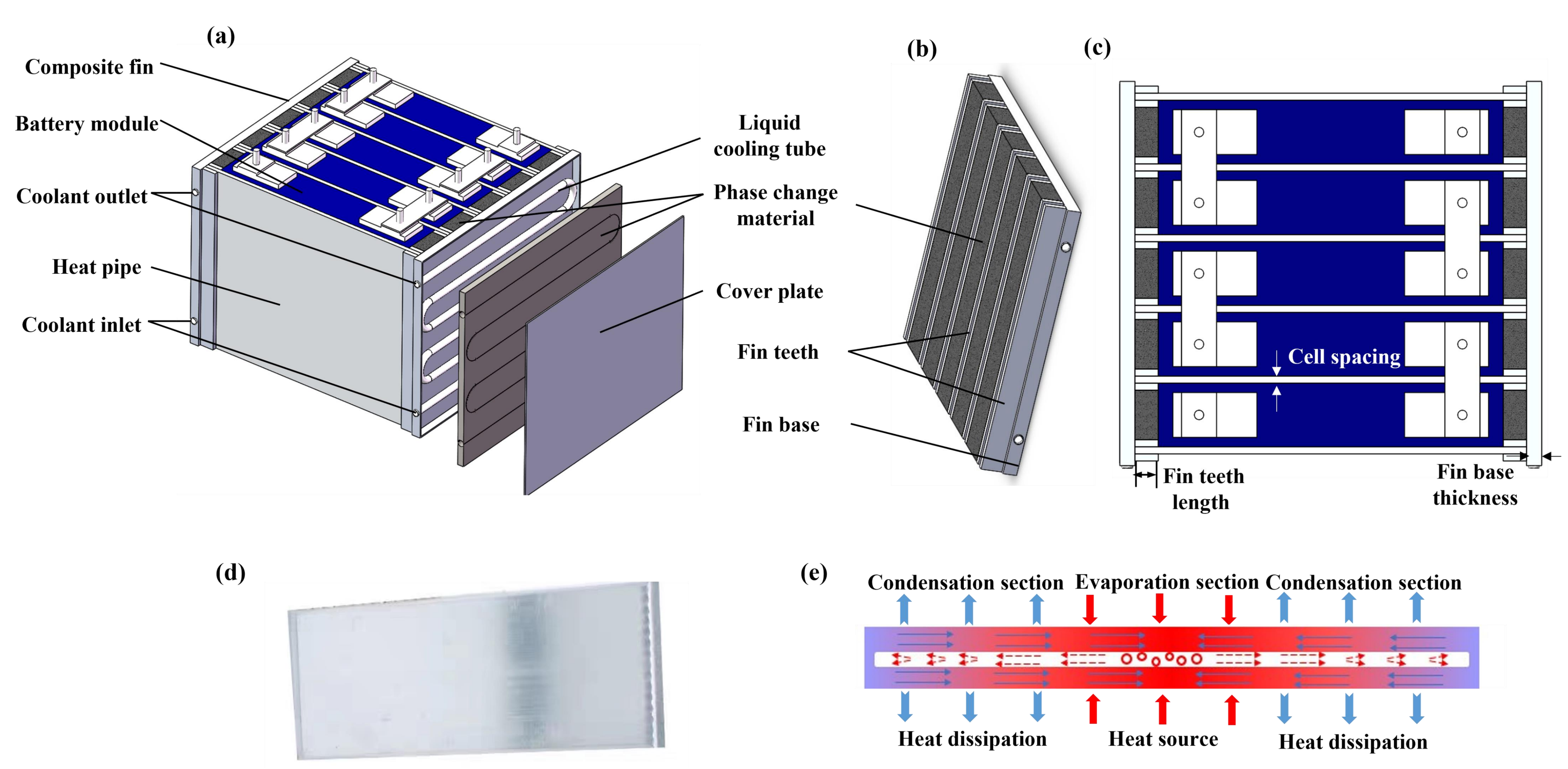


FIGURE 1. The structure of the designed model: (a) the BTMS, (b) the composite fin, (c) the top view, (d) heat pipe structure, (e) heat pipe's working principle.

Methodology

Battery model $E_b = E_{OCV} + \eta_{ohm} + \eta_{pol}$

Heat production model of battery

$$Q_b = \left(\eta_{ohm} + \eta_{pol} + T\frac{\partial E_{OCV}}{\partial T}\right) I$$

Thermal model of PCM $c_{cpcm} = \sum_{i=1}^{n} \theta_i c_i + L \cdot D$

$$TGC = \eta_1 \times \eta_2 \times \eta_3 = \frac{40\%M_b - M_s}{40\%M_b} \times \frac{50 - T_{max}}{50 - T_{amb}} \times \frac{5 - \Delta T_{max}}{5}$$

Results

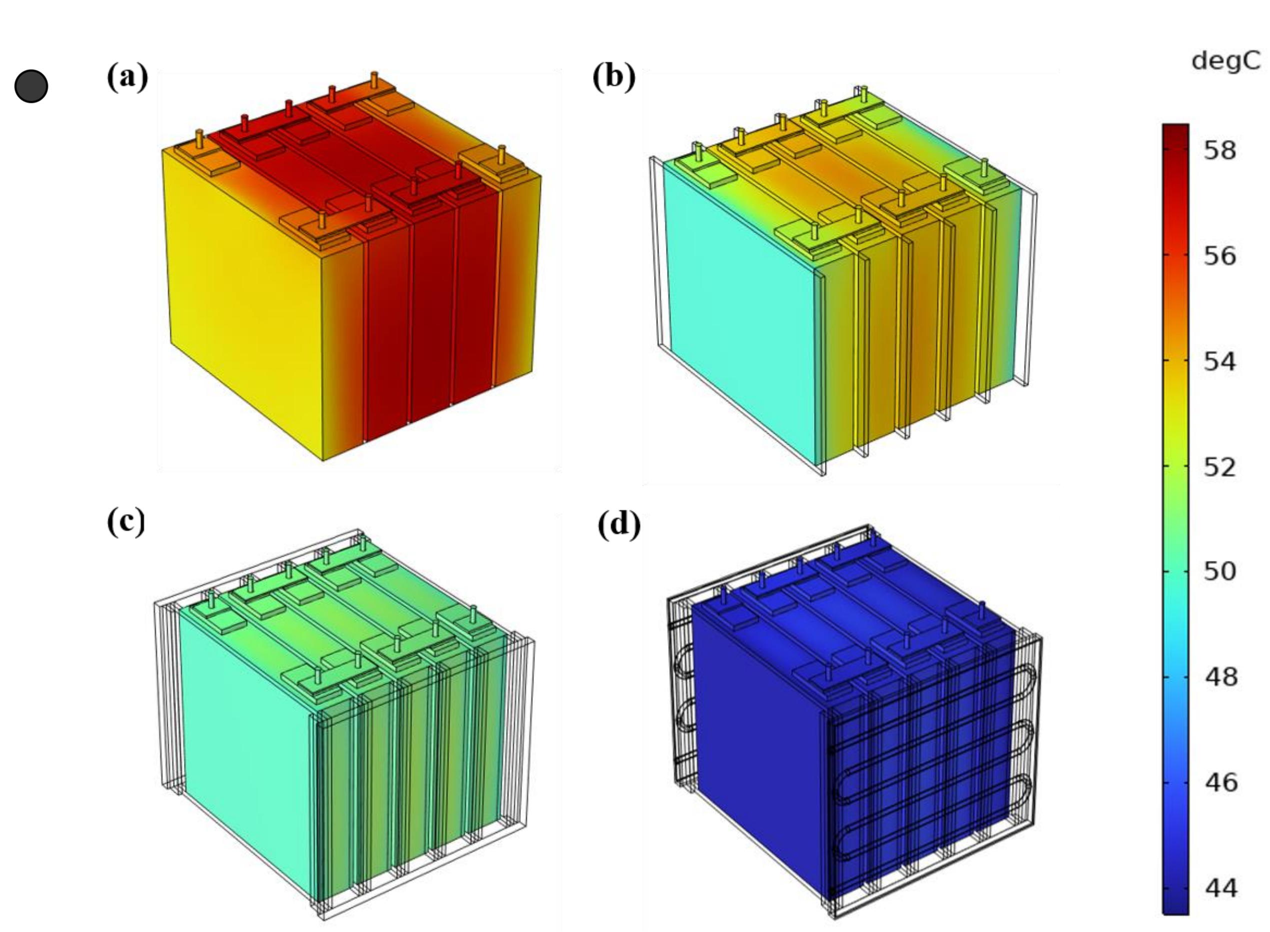
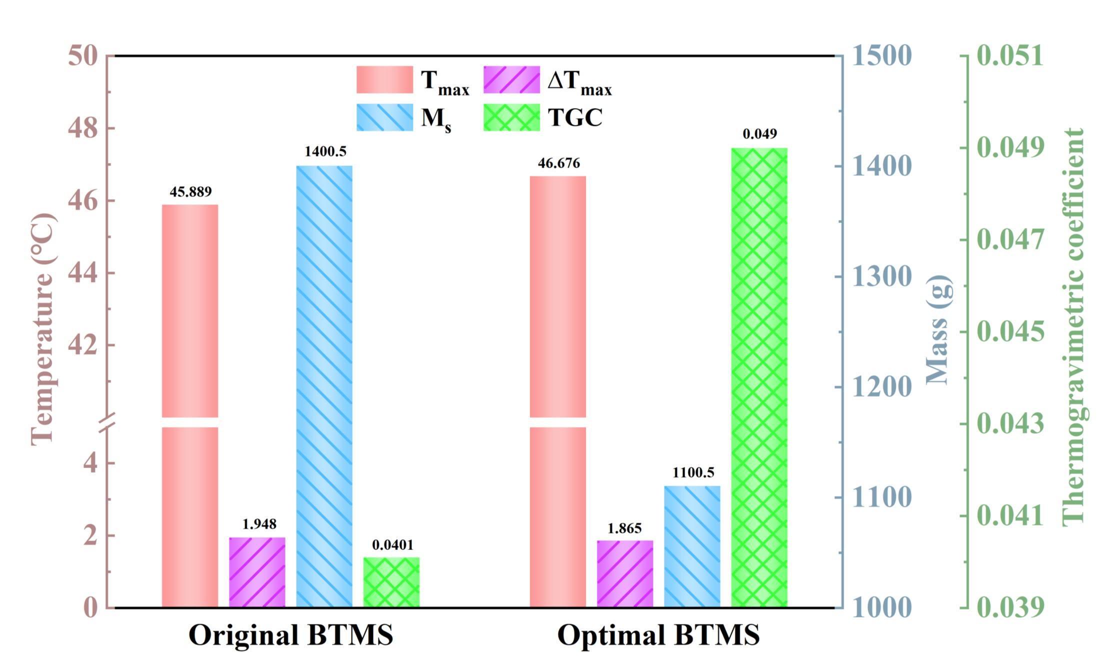


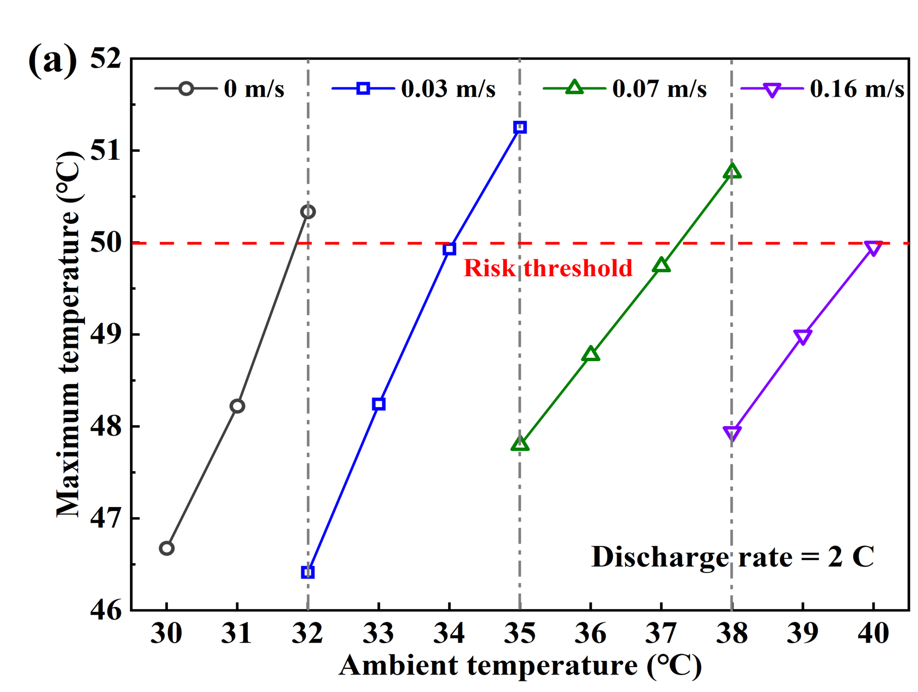
FIGURE 2. Temperature distribution of different passive cooling systems: (a) natural cooling (NC), (b) single heal pipe cooling (SHP), (c) heat pipe coupling traditional fin cooling (HPTF), (d) heat pipe coupling composite fin cooling (HPCF).

The systems of NC, SHP and HPCF show poor temperature performance, while the T_{max} and ΔT_{max} of the HPCF are only 45.9 ℃ and 2 ℃



By single parameter and response surface analysis, the comprehensive performance of the HPCF was improved by 22.19%.

FIGURE 3. The comparison of system performance before and after optimization.



The optional liquid cooling strategy can meet the battery heat dissipation requirements and minimize the energy consumption and mechanical losses

FIGURE 4. Maximum temperature of the battery module at the optimization strategy .

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