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Short communication

Research on the heat dissipation performance of battery pack based on forced air cooling

X.M. Xu*, R. He

School of Automotive and Traffic Engineering, Jiangsu University, Zhenjiang 212013, China

HIGHLIGHTS

- Changing longitudinal battery pack into horizontal battery pack, it could improve the heat dissipation performance by shorting airflow path.
- The heat dissipation performance of battery pack with double "U" type duct basically met the design requirements at different temperatures.
- When the heat dissipation condition was poor, it could reduce the SOC state to satisfy the heat dissipation performance requirements.
- It could reduce the charge and discharge rate to satisfy the heat dissipation performance requirements.
- Comparing with the practical operation condition of battery pack, it met the heat dissipation performance requirements.

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ABSTRACT

Electric vehicle cooling modes are divided into air cooling, liquid cooling and phase change material cooling, the air cooling is divided into natural air cooling and forced air cooling. This paper selects the forced air cooling as the study object, and researches the heat dissipation performance of different airflow duct modes, the results indicated that: as considering that changing the longitudinal battery pack into horizontal battery pack, it could improve the heat dissipation performance by shorting airflow path; it increases the contact area for thermal conduction by adding bottom duct, and the area of battery pack top exists natural convection, so the heat dissipation performance of bottom duct mode is more superior; for battery pack with bottom duct mode, it uses the double “U” type duct instead of double “1” type duct in order to improve the heat dissipation performance; when the heat dissipation condition is poor, it could reduce the SOC state or charge & discharge rate to satisfy the heat dissipation performance requirements; as considering the practical operation condition of battery pack with double “U” type duct, it has a large margin of high charge and discharge rate to meet the needs of electric vehicle acceleration or deceleration operation.

It is widely used the forced air cooling as the cooling method of battery pack at home and abroad [1–3], many researchers have carried out the related work: for battery pack arrangement, Takaki [4] separated the forced air cooling into serial airflow and parallel airflow; the forced air cooling system developed by Toyota corporation was the most representative, and the relevant patents were applied [5]; Pan [6] researched the heat dissipation performance of Hybrid-Electric vehicle battery pack by software STAR-CD and ANSYS, and validated by experiments; Fu [7] researched the thermal management system of Ni-MH battery pack; Zhu [8] researched the thermal management system of electric vehicle battery pack, and analyzed the cooling system structure design of Toyota RAV-4 electric vehicle; when the speed of electric vehicle was constant, Liu [9] researched the temperature field of lithium-ion battery pack based on natural air cooling by simulation and experiment. In addition, there are many forced air cooling system of battery pack developed by researchers and manufacturers [10–12], in order to improve the temperature distribution uniformity of battery module.

This paper selects the forced air cooling of battery pack as the study object (the battery pack has a total of 48 batteries, and includes 4 battery modules with 2 parallels and 6 series), and researches the heat dissipation performance of different airflow duct modes, in order to offer a reference basis for heat flow field characteristic analysis of battery pack and airflow duct mode choosing.

* Corresponding author. Tel.: +86 13795269280.
E-mail address: xuxiaoming3777@163.com (X.M. Xu).

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Table 1
Thermal physical parameters of 55Ah lithium-ion battery.

Battery component	Density ($kg(m^3)^{-1}$)	Thermal conductivity coefficient ($W(m\ K)^{-1}$)	Specific heat capacity ($J(kg\ K)^{-1}$)
Electric core	2123	30.6	913
The positive pole	2719	202.4	871
The negative pole	8978	387.6	381
The diaphragm	1008	0.3344	1978
Shell	8193	14.7	439.3

1. Thermal power determination test of 55Ah lithium-ion battery on charge and discharge processing

1.1. Thermal physical parameters of 55Ah lithium-ion battery

Table 1 shows the thermal physical parameters of 55Ah lithium-ion battery: the density of electric core is 2123 $kg(m^3)^{-1}$, the thermal conductivity coefficient is 30.6 $W(m\ K)^{-1}$, and the specific heat capacity is 913 $J(kg\ K)^{-1}$.

1.2. Thermal power determination test of 55Ah lithium-ion battery on charge and discharge processing

Fig. 1 shows the arrangement of temperature measuring point and the design of thermal insulation with 55Ah lithium-ion battery, including 2 measuring points on bottom and 3 measuring points on side wall, heat insulation box has three layers of insulating material surround, in order to ensure good thermal insulation performance.

Calorific value calculation formula is as follows:

$$Q = c_p m \Delta T \tag{1}$$

Q means calorific value; c_p means specific heat capacity; m means quality; ΔT means temperature rising.

It could be introduced into the thermal power calculation formula by Formula (1) as follows:

$$P = \frac{c_p m \Delta T}{t} \tag{2}$$

P means thermal power; t means time.

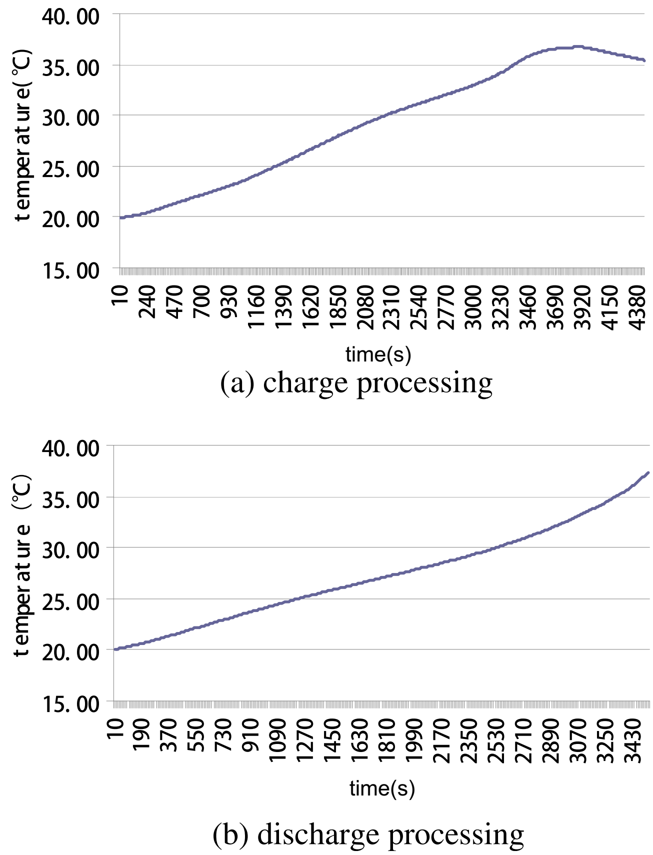
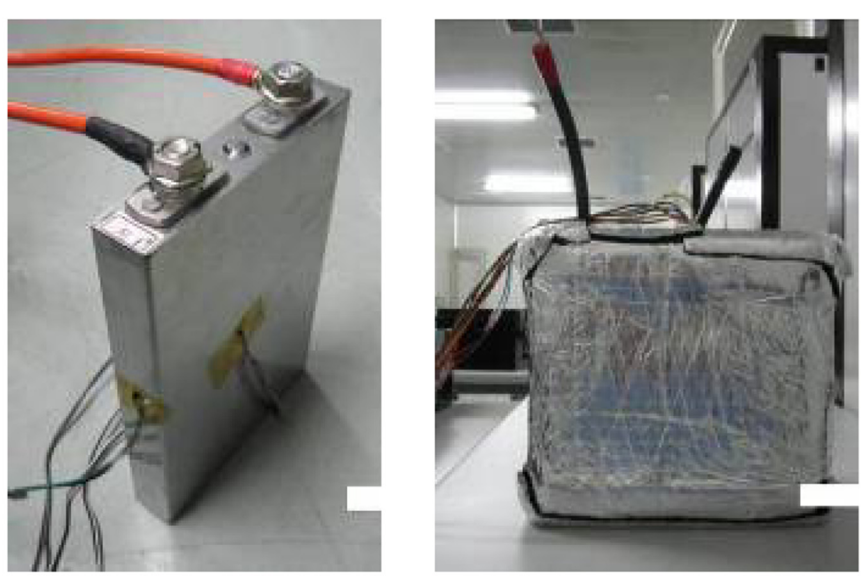


Fig. 2. When the environmental temperature is 20 °C, the average temperature curve of 55Ah lithium-ion battery on charge and discharge processing.

Constant temperature box is set to suitable temperature, the experimental processing is as follows: firstly, setting 1C charge rate up to 3.65 V; secondly, turning to constant-voltage charge, until 0.05 C cutoff; thirdly, setting 1C discharge rate down to 2.50 V.



(a) Temperature measuring point (b) Heat insulation box

Fig. 1. The arrangement of temperature measuring point and the design of thermal insulation with 55Ah lithium-ion battery.