Feasibility Study of Battery Cooling System based on M-Cycle Evaporative Cooling

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【Purpose】

The purpose of this study is to explore whether M-cycle, as an evaporative cooling system, can stabilize the temperature of the battery within a certain range and make it not fail. The specific battery working temperature is judged with reference to the standard of American Battery Association (20-40 degrees Celsius) and the standard of no more than 52 degrees Celsius proposed by Freedom Car, a well-known American automobile website.

【Method】

A fully enclosed evaporative cooling system based on semi-open M-cycle system is proposed to cool power batteries. The battery is located inside the system. As shown in Figure 1.

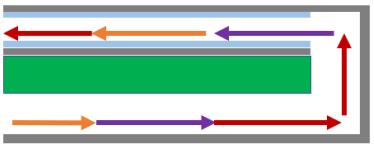


Figure 1. Closed M-cycle cooling box

The model consists of two parts, the lower part is called dry channel and the upper part is called wet channel. The green part is the battery. In order to facilitate the calculation, the blade battery with regular shape is selected. The battery works to generate heat, which is divided into two directions, that is, the battery in the dry channel transfers heat to the flowing air, and thermal convection occurs. And heat transfer through the inner wall of the dry channel into the wet channel.

The heat transfer formula is given below.

In the dry channel, the battery transfers heat (thermal convection) to the air.

$$Tb = T_{bO} + \frac{\emptyset \times t - hA \times \Delta T}{m \times C_b}$$

In the wet channel, the heat (heat conduction) transmitted from the inner wall of the dry

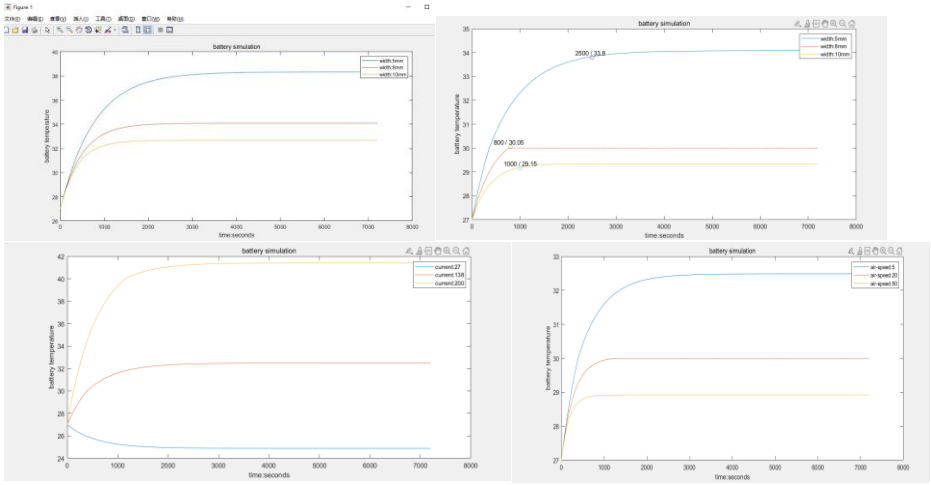
channel is accepted, which leads to the evaporation of water in the wet channel. The mass of evaporated water is calculated and multiplied by the humidity difference and enthalpy difference at the inlet and outlet of the wet channel. As a result, the energy needed to evaporate the water can be considered to be transmitted by the dry channel.

$$\frac{H_w \times D \times l \times \rho \times \quad (\hbar'' - \hbar) \quad \times \quad (d' - d)}{m \times Cb}$$

The battery temperature is obtained by subtracting the two formulas.

【Graph】

Through MATLAB simulation, the following figure is obtained.



The control variable method is used to change the height of the main channel, the working current of the battery and the wind speed of the system. Explore the impact on the entire cooling system.

【結果】

Compared with pure air cooling cycle and double cooling cycle, it can be found that the cooling effect of M-cycle cooling box with double cooling cycle is outstanding.

M-cycle can cool the single blade battery internally, and the final battery temperature is about 33.8 degrees. At the same time, it is known that changing the height of dry and wet channel, battery discharge current and system wind speed can improve the cooling efficiency of the system.

It can be seen from the simulation that the M-cycle cooling box with dual air cooling cycles has excellent cooling capacity.