Improving the cooling performance of cylindrical lithium-ion battery using three passive methods in a battery thermal management system

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ABSTRACT

Developing a high-performance battery thermal management system (BTMS) to keep the temperature of lithium-ion battery (LIB) in a suitable range has become of great interest for electric vehicle (EV) applications. Hence, this study has been set out to design a BTMS by utilizing various combination of phase change material (PCM), metal foam, and fins that keeps the battery surface temperature at the lowest level in normal and harsh environmental conditions under discharging with 3C current rate. Considering these three passive methods, four different cases of BTMS have been designed separately. Moreover, the effects of various fin shapes including rectangular, triangular, trapezoidal, I-shape, and wavy fins are studied for the optimum BTMS. The two-equation local non-equilibrium thermal model has been used which is more precise than the traditional thermal equilibrium model in simulating heat transfer between the PCM and metal foam. The numerical results demonstrated that the optimum BTMS, which is the combination of PCM, metal foam, and fins (fourth case), can reduce the battery surface temperature by 3 K. Furthermore, the maximum delay of about 470 s in melting of the PCM has been reported for this case. Additionally, the applied fins in the fourth case are acting as a network of heat sources to spread heat in the middle of the system, and utilized metal foam can create a uniform distribution of heat between LIB and ambient. Analyzing the effect of different fin shapes on the performance of optimum BTMS showed that there are no remarkable changes between the battery surface temperature of various fin shapes and it would be hard to find a suitable shape of fins for all environmental conditions.

KEYWORDS

Battery thermal management system; Cylindrical lithium-ion battery; Fin; Heat transfer enhancement; Metal foam; Phase change material

ACKNOWLEDGMENTS

The authors would like to acknowledge the financial support from the Universiti Malaysia Pahang through the PGRS grant with the number PGRS220326 and the Malaysian Technical Corporation Programme, Ministry of Foreign Affairs. The first author would like to also thank Mr. Amiratabak Azarinia for his help in writing some lines of the User Defined Function (UDF) code.