Modeling the effect of cooling path design on the thermal behavior of a lithium-ion battery pack

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The lithium-ion battery (LIB) is a preferred power source for Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) applications due to its high energy density, high voltage and low self-discharge rate. However, thermal problem such as thermal runaway and non-uniform temperature distribution of battery packs remains a serious challenge in the LIB industry. An uneven temperature rise in packs could lead to electrically and thermally unbalanced cells and thus lead to lower performance, shorter battery life. It is, therefore, important to control accurately the uneven temperature distribution in the battery pack.

In this work, a three-dimensional modeling is carried out to investigate the effects of various cooling path designs on the thermal behavior of the LIB pack. The operating conditions considered were the flow rate of cooling liquid. Heat generation rate in a cell is calculated by using the modeling results of the potential and current density distributions of a battery cell.

Fig.1 shows the schematic diagrams of battery packs with two types of active cooling path composed of 18 cells.

The temperature distribution in the battery pack after 1525 seconds with heavy duty urban dynamometer driving schedule (HD-UDDS) cycle without any active cooling is shown in Fig. 2 (a). The temperature distributions in the battery pack at the same condition with an active cooling by ethylene-glycol 50% in cooling path type 1 and cooling path type 2 are shown in Fig. 2 (b) and (c). The mass flow rate of ethylene-glycol 50% is 2.49kg/s.

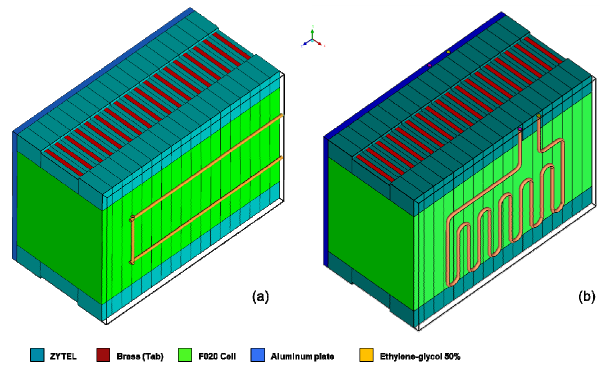

Fig.1. Schematic diagrams of battery packs: (a) cooling path type 1 and (b) cooling path type 2.

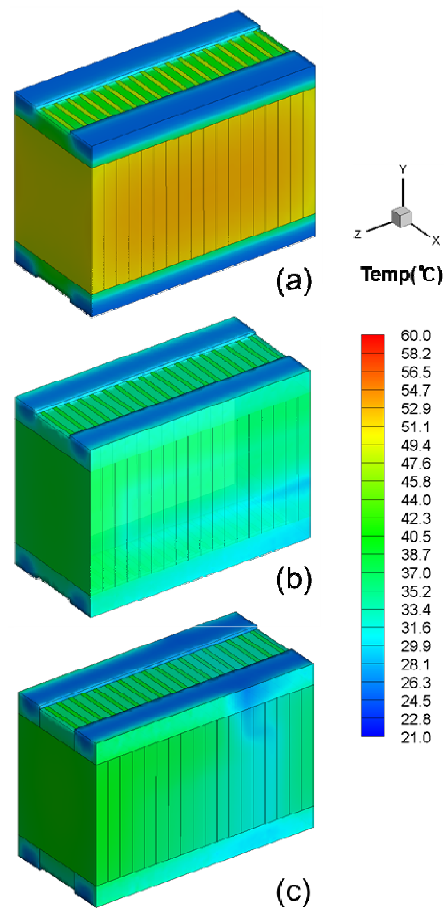

Fig. 2. Temperature distributions of LIB packs after the 1525 seconds with HD-UDDS cycle profile: (a) without active cooling, (b) with active cooling in cooling path type 1 and (c) with active cooling in cooling path type 2.