Thermal Management of Lithium-Ion Battery Packs

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Abstract

A design for the thermal management of Lithium-ion battery packing as used in hybrid and electric vehicles has been developed. The design satisfies all thermal and physical issues relating to the battery packs used in vehicles including operating temperature range and volume, and, should increase battery cycle life, and, charge and discharge performances. Particular attention was devoted to the thermal management of batteries operating in extreme temperature conditions, that is, from -50 °C to +50 °C, with desired operating conditions held between 20 °C and 30 °C. The method of cooling/heating here could be thought akin to a heat sink approach with heat removed or added using water. This current work is a series of simulations used to give sound indications for the design and assembly of a prototype.

The aim of a thermal management system is to maintain a battery pack at an optimum average temperature, as dictated by life and performance trade-off. It is important that an even temperature, perhaps with small variations, is maintained between the cells and within the pack. However when designing such a system, regard must also be paid to the fact that the battery pack should be compact, lightweight, have low cost manufacture and maintenance, and have easy access for maintenance. The management system should also have low parasitic power, allow the pack to operate under a wide range of climatic conditions and provide ventilation if the battery generates potentially hazardous gases. The thermal management control strategy is enacted using an electronic control unit. A general schematic of the proposed thermal management system is given on Figure 1 and Figure 2. The method employed is fundamentally to surround the cells with a conducting material, that is, a form of heat sink, and remove or add heat using fluid.

Typical velocity contours for the battery pack are shown on Figure 3. The important aspect here is that heat could be added/removed to the water in the plenum chamber efficiently. It can be seen that there was slow moving water adjacent to the heating/refrigerator unit hence giving enough time for absorption/dissipation of heat.

A series of tests were conducted on the battery pack which had, in addition to initial temperatures of 313.15 K and 349.15 K, an internal heat source for each cell of either 0.25, 0.5 or 1 W. Results for the pack with cells each having an internal heat sources of 1 W are shown on Figure 4. As with the previous tests, what was important was the control of temperature between acceptable limits, and a good uniformity of temperature across each cell.

Reference

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Figures used in the abstract

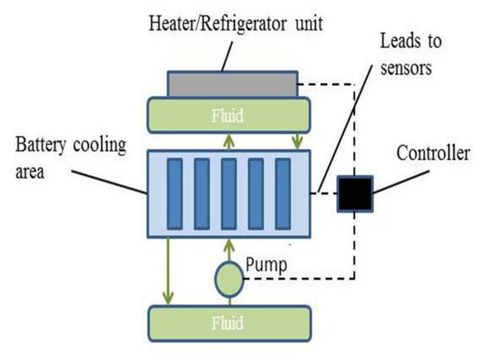

Figure 1: Schematic of thermal management system.

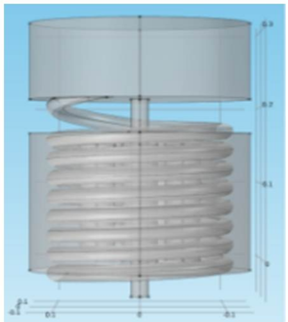

Figure 2: . Battery cooling area

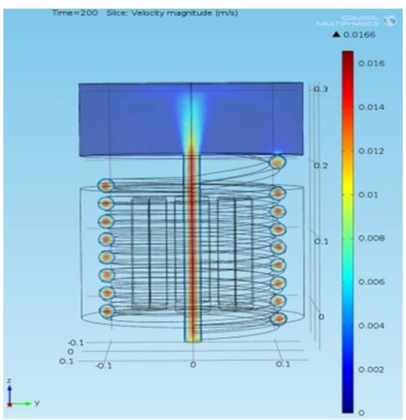

Figure 3: Velocity contours $u_{in}=0.01$ m/s, $T_{in}=20°C$, $r_{inner}=10$ mm, and $T_0=20°C$.

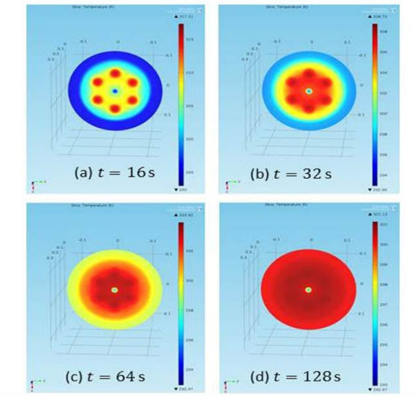

Figure 4: Front views of temperature profiles in two adjacent cells for T_init =313.15 K, u_in=0.01 m/s