Part 03

Developing Effective Heat Control Measures for Lithium Ion Batteries

Cooling Techniques Used in Automotive Lithium Ion Batteries

The ratification of the Paris Agreement as the global framework for dealing with climate change brought the introduction of various fuel efficiency and CO2 emissions standards throughout the world. A major shift from the internal combustion engine (gasoline and diesel) to electric drive cars as well as advances in the electrification of cars is certain.
The highly concentrated placement of lithium ion (Li-ion) batteries in automotive applications demands highly efficient cooling mechanisms capable of maintaining battery durability and requiring little space.
GS Yuasa developed the LEV50 Li-ion battery cell in 2008. The LEV50 cell was the first of its kind mass-produced for use specifically in electric cars[1] . Since then we have continued to develop automotive battery cells and battery modules. This article will explore the technical concepts developed by GS Yuasa for cooling automotive Li-ion batteries.

1. Bottom Cooling Prismatic Cells

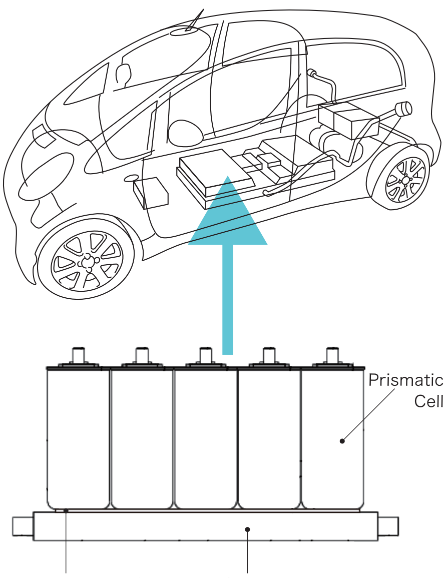
Batteries may be air- or liquid-cooled. Air cooling systems tend to be of simple design and liquid cooling systems, while they tend to be more complex, tend to provide much better cooling performance. One requirement for electric vehicles (EVs) is increasing the driving range. However, increasing the driving range requires a high concentration of the batteries that power the vehicle drivetrain to be arranged in a limited space. Prismatic Li-ion cells are well suited for this kind of high density placement.

GS Yuasa devised the LEV50-based modules to provide these very features. The module includes multiple prismatic cells arranged side by side with a heat transfer sheet underneath the cells over a cooling plate (●Fig. 1).

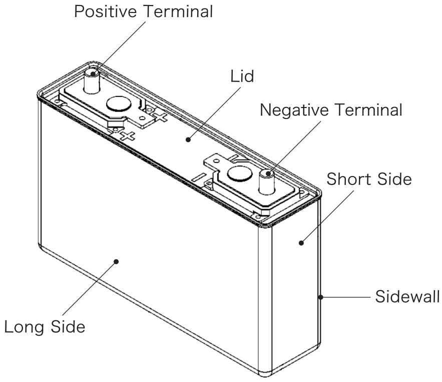
A prismatic Li-ion cell is typically provided with the positive terminal and the negative terminal in the case lid (●Fig. 2). The case lid and bottom wall opposite the lid are rectangular and connected via sidewalls. One pair of sidewalls make up the long side of the case, i.e., include a large surface area, and the other pair of sidewalls make up the short side of the case, i.e., include a small surface area.

One way to cool the prismatic cell is to place the cooling plate in contact with the long side of the cell. However, the long side of the cell tends to deform, expanding and contracting with the charging and discharging of the cell, since the long side has a large surface area. The deformations create a gap between the cell and the cooling plate and the thermal insulation properties of air prevent heat transfer from the cell to the cooling plate, and thus reduces the efficiency of the cooling plate. Additionally, options for improving space economy and energy density are limited when the cooling plate is at the long side of the cell.

●Fig. 1 Cooling via Heat Transfer Sheet[2]



●Fig. 2 External View of a Prismatic Cell



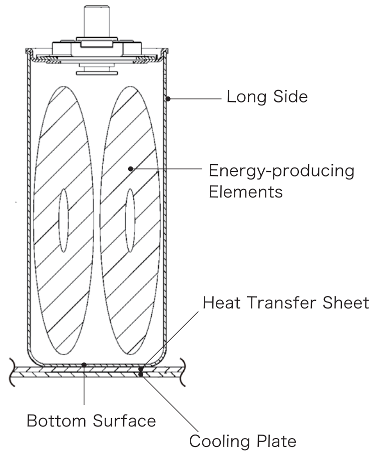
GS YUASA

Therefore, in our design multiple prismatic cells are lined up at the long sides as illustrated in ●Fig. 1. The cells are in contact with the cooling plate via a heat transfer sheet along the bottom (or the short side) of the cell. The heat transfer sheet may be a composite resin that is more thermally conductive than air. The cooling plate may contain a liquid circulating inside to provide even better cooling performance.

The energy-producing elements inside the cell case touch the long side of the cell and sit slightly above the bottom of the case, leaving a gap (●Fig. 3). Note that the bottom surface of the case tends not to expand and contract since it has a smaller surface area than the long side of the case.

No gaps form between the cell and the cooling plate when a heat transfer sheet is interposed therebetween at the bottom surface of the case. This allows heat to travel unimpeded from the cell to the cooling plate. Additionally, multiple prismatic cells may be densely arranged over the heat transfer sheet on a single cooling plate (●Fig. 1). Thus, the cells can be kept cool and enough cells may be put together to provide high energy density.

●Fig. 3 Inside a Prismatic Cell



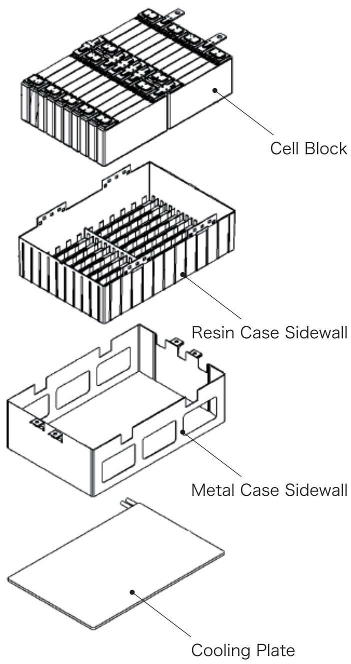
2. A Module Case Suited to Bottom Cooling

A battery module may be built by enclosing the multiple prismatic cells in a resin case to electrically insulate the cells; the resin case may then be housed in a metal case. The metal case is stronger than the resin case and is suited for securing the battery module in a vehicle. Here, the resin case should remain stationary inside the metal case so that the cell is resistant to vibrations or impact. Modules built on our above-described technical concept do not require spaces around or between cells to allow for bottom cooling multiple prismatic cells. Furthermore, the frame-like metal case fully surrounds the resin case without covering the bottom surface of the cells so that the cooling plate can cool the cells (●Fig. 4).

More specifically, when building a cell block comprised of one or multiple rows each containing multiple prismatic cells, the cell block is surrounded by a resin case that serves as the sidewalls. The resin case is then enclosed in the metal case. The metal case has no bottom and so the cooling plate covers the bottom end of the metal case. Here, a heat transfer sheet may be placed between the cooling plate and the bottom surface of the cells.
Because the metal case is constructed to support the resin case in this type of module case, the resin case is held firmly in the metal case. Therefore, there is no need to separately attach or secure the resin case inside the metal case. This battery module structure is not only compact but also ensures that the cooling plate is still effective even if the cell is heating up rapidly and expanding when fast charging the battery, for example.

This article described some concepts we created for effectively bottom cooling lithium ion batteries used in automotive applications. GS Yuasa will continue to forge ahead relying on its considerable experience developing battery cells and battery modules to contribute to the global drive to electrify our cars.

●Fig. 4 Bottom Cooling Module Case[3]



1. GS Yuasa Technical Report Volume 5, No. 2, published 2008
2. Japanese Patent No. 5804323, Japanese Patent No. 6020942, European Patent No. 2475025, US Patent No. 8846226, US Patent No. 9509022, Chinese Patent No. 201210003942.6, Chinese Patent No. 201510738725.5, Korean Patent No. 101736886, German Utility Model No. 202012013288, German Utility Model No. 202012013315 (Filed in 2011)
3. Japanese Patent No. 5796785, Japanese Patent No. 6011950, Japanese Patent No. 6020974, US Patent No. 9252406, US Patent No. 9515306, German Utility Model No. 202013012270 (Filed in 2012)

For inquiries, contact:
Intellectual Property Division,
GS Yuasa International Ltd.