Part 06

Making History: The Large Format Lithium Ion Battery

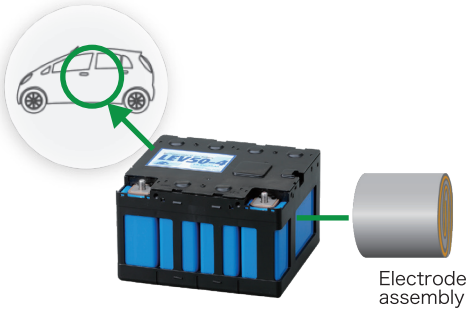
Increasing Battery Capacity While Maintaining Form Factor

In Part Five of this series we discussed improvements to a bolt terminal lock structure and battery sealing structure. In this Part Six we will discuss techniques we developed to reduce the size of these structures, to preserve the strength of the battery case and the insulation surrounding the conductive path thus enabling us to provide greater battery capacity.

There is always a demand for increased cell capacities for batteries used in electric vehicles (●Fig. 1). Greater cell capacities can help increase the range of the electric vehicles.

The electrode (electrode assembly), which is the power generating and storage element housed in the battery case, should be as large as possible to increase the cell's capacity. As previously discussed, GS Yuasa came up with various ways to minimize the dead space within the battery case. By devising ways to arrange the electrode and alternate shapes for the collector (Part One and Part Two in this series), we are able to store a larger electrode within the battery case. In order to store an even larger electrode without changing the outer dimensions of the battery case, we turned our attention to providing a thinner lid structure on the battery case.

●Fig. 1 Battery and Electrode for an Electric Vehicle

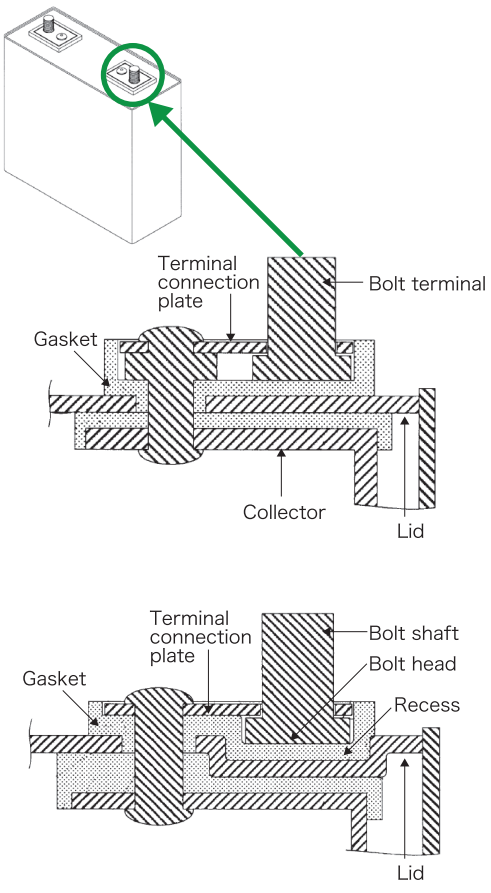


1. Increasing the Electrode Housing Space

Typically the outer surface of the battery case lid is flat, with the gasket placed on top of the flat lid (upper,● Fig. 2). The bolt terminal and the terminal connection plate are placed on top of the gasket. If the lid is stainless steel, the lid may be made thinner without altering its mechanical strength thus increasing the housing space inside the battery case.

To provide an even thinner structure, however, we proposed collapsing the battery case lid inward, and shaping the gasket to match the recess in the lid (lower, ●Fig. 2). The recess is formed in the outer surface of the lid through press machining. A recess is also formed in the gasket with the head of the bolt terminal housed in the recess of the gasket. This kind of structure shortens the distance between the lid and the terminal connection plate which is seated on the head of the bolt terminal. Compare, for instance, the height of the terminal connection plate when both the lid and the gasket have recesses (lower, ●Fig. 2) with the height of the terminal connection plate when there are no recesses (upper, ●Fig. 2). In the former case the inner surface of the lid can be placed higher to increase the space inside the battery case.

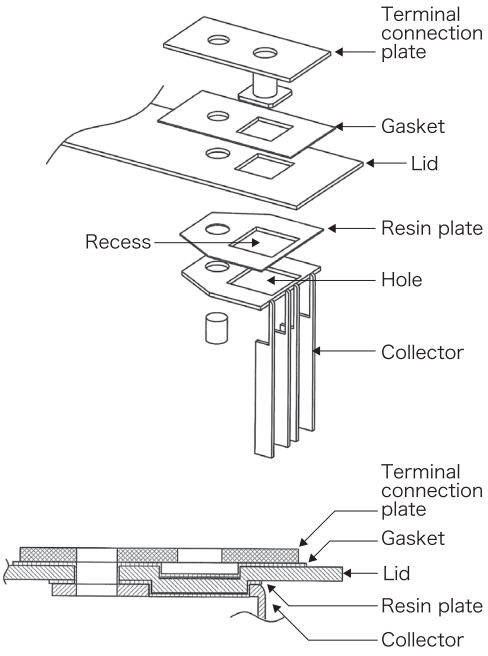
●Fig. 2 Lid Structure for the Battery Case[1]



Building on this iteration of a thinner lid, GS Yuasa then adds a recess to the resin plate inside the lid, and a matching hole in the collector (upper, ●Fig. 3).

In more concrete terms, the convex part at the inner surface of the recess in the resin plate protrudes downward and fits snugly in the hole in the collector (lower, ●Fig. 3). With this structure, the collector may be positioned higher up, further increasing the space inside the battery case.

●Fig. 3 Lid Structure with Hole in the Collector[2]



2. Increasing the Insulation Distance

Electric vehicles require high voltages in the hundreds of volts. In that kind of environment, the insulation in the individual cells must ensure that no current flows outside the conductive path. However, as described above, increasing the capacity of a cell requires reducing the thickness and profile of the parts and structures in the cell. GS Yuasa therefore devised a structure capable of providing good insulating properties even with a thinner resin plate arranged at the inner surface of the lid.

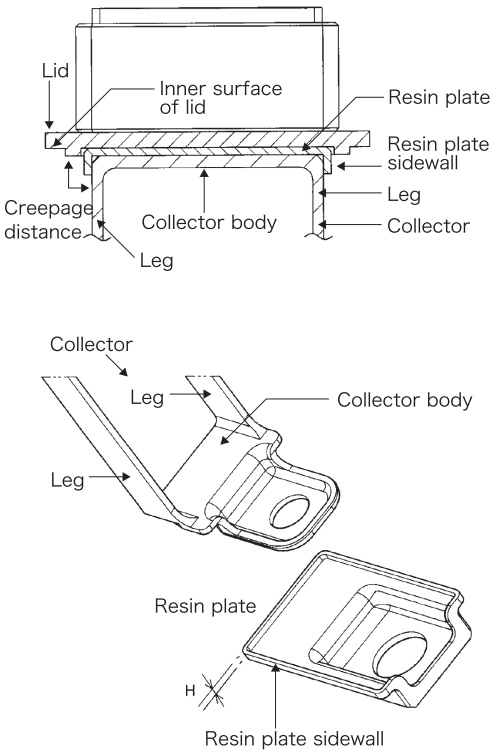
In this structure (upper, ●Fig. 4), a resin plate is placed between the metal battery case lid and the metal collector (collector body). The edges of the resin plate are provided with sidewalls made from the same resin. The sidewall is taller than the thickness of the collector body. Collector connecting plates (or, "legs") connecting to the electrode extend from the collector body; the resin plate sidewalls cover the outer surface of the legs where the legs extend from the collector body (lower, ●Fig. 4).

Without the resin plate sidewalls, there is no insulating material separating the portion near where the legs connect to the collector body and the metal lid. There is little insulating thickness. Note that the insulating thickness takes into account the spatial (linear) distance between exposed metal surfaces, and the creepage distance, which is the distance along the surface of the insulating material between metal components.

GS Yuasa provides sidewalls on the resin plate to cover the outer surface of the legs with the sidewall and increase the insulating thickness (creepage distance) between the lid and the collector. This structure provides good electrical insulation and a thinner resin plate.

Building on each of these technical innovations leads to continuous improvements in the product. With this constant development and improvement, the large format lithium ion battery will certainly continue to evolve.

●Fig. 4 Insulation structure developed by GS Yuasa[3]



1. Japan Patent No. 5588712 (Filed in 2010)
2. Japan Patent No. 5592844 (Filed in 2011), U.S. Patent No. 9034513 (Filed in 2013)
3. Japan Patent No. 5742260, U.S. Patent No. 8945762, European Patent No. 24823601, China Patent No. 201210021287.7, Korea Patent No. 10-1658263 (Filed in 2011)

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