Part 02

Making History:
The Large Format Lithium Ion Battery

Innovations in the Collector Structure and in Production

In Part One, we highlighted some of the technological transitions leading up to the introduction of prismatic cases and vertically oriented electrodes in the large lithium ion batteries manufactured by GS Yuasa. This article discusses development of the collector – an important element in large format batteries. A collector is a metal element used to transfer the electricity accumulated in the electrode inside the battery case to an electric load.

1. Unique Developments by GS Yuasa

Previously, we discussed GS Yuasa' s small lithium ion LP Series batteries developed in 1995 (●Fig. 1). GS Yuasa was one of the first in the industry to use a vertically oriented electrode in this LP Series.

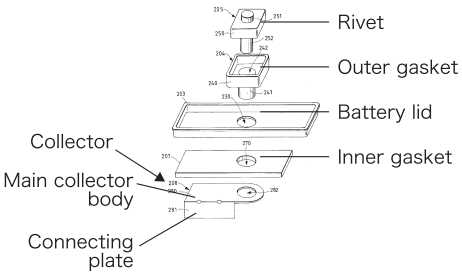
The collector used in the LP Series (●Fig. 2) had a main collector body positioned parallel to a battery lid. There was also a short connecting plate extending from the main collector body. The short connecting plate connected an end of the vertically oriented electrode (not shown) to the main collector body. Finally a rivet shaft was inserted through the outer gasket, battery lid, and inner gasket and was secured to the main collector body.

The integrated design in the small LP series batteries, prompted a new collector structure in the "LIM Series," of large lithium ion batteries launched by GS Yuasa in 2002 (●Fig. 3). One distinctive attribute of the LIM series collector is its unconventional shape.

A LIM series battery contains a lateral pair of collectors. Each collector includes a plate-like main collector body positioned above the curved part of the vertically oriented electrode and connecting plates extending from one edge of the main collector body (●Fig. 4). The connecting plates are bent to extend parallel to the outer surface of the electrode and are welded to the end of the electrode. This design allowed us to place the collector in the corner of the battery case and as a result, provide the largest possible electrode in a limited amount of space. The long connecting plates of the collector also acted as a vibration damper for the electrode inside the battery case.

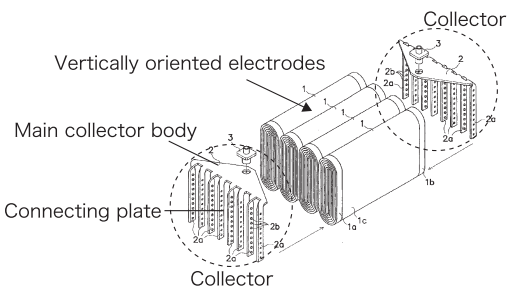
●Fig. 1 The LP Series Batteries

●Fig. 2 Collector in the LP Series[1]



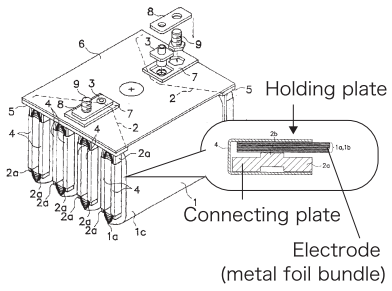
●Fig. 3 LIM40 battery

●Fig. 4 Collector in a LIM Series battery[2]



Another distinctive attribute of the LIM series collector is that the electrode is sandwiched between a thin metal plate and the connecting plate. The metal foil bundle at the end of each vertically oriented electrode is divided into halves down the center of the bundle, and only one of the two halves is welded to one of the connecting plates. More specifically, one half of the metal foil bundle is sandwiched between the connecting plate and the thinner metal plate (holding plate), and the assembly is then ultrasonically welded together (●Fig. 5).

●Fig. 5 Collector structure for LIM Series[3]



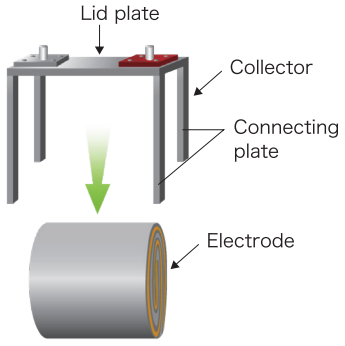
The thin holding plate sufficiently transmits ultrasonic waves through to the electrode. Thus, there was no need to increase the ultrasonic output during welding, and we were able to securely weld the electrode onto the connecting plate via the holding plate. We were also able to ensure multiple joins (a large joining area) between the electrode and connecting plate, and we were therefore able to provide large-current charging and discharging capacities thanks to the long connecting plate.

Although there have been various developments and improvements, this basic collector structure is still widely used in large lithium ion batteries. The technique of providing a thin metal plate to improve welding is also being used, even today. What is relatively unknown is that this invention sprung from the idea of the vertically oriented electrode and the collector shaped to suit that electrode for a small lithium ion battery, and that both the technique and the structure were developed independently by GS Yuasa.

2. Innovation in the Battery Production Process

GS Yuasa also created a production process that dramatically improved the yield for its large lithium ion batteries.

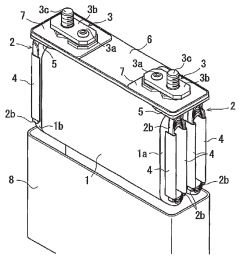
●Fig. 6 The assembly process



First, the lid plate and the collector are secured together (top, ●Fig. 6). The connecting plate and the end of the electrode (the metal foil bundle) are then joined together. Finally, the electrode is inserted into the battery case while the electrode is hanging from the lid plate (●Fig. 7).

This production process brought dramatic improvements to the yield for large lithium ion batteries. The join between the connecting plate and the electrode is delicate; if we try to join the connecting plate and electrode first, and then secure the collector to the lid plate, the join will likely peel off. Securing the lid plate and the collector first and then joining the collector and the electrode, maintains a satisfactory join between the collector and the electrode. The procedure further simplified the work of inserting the electrode into the battery case. It is possible to insert multiple electrodes simultaneously and without problems, particularly when multiple vertically oriented electrodes are being inserted into the case.

●Fig. 7 LIM Series assembly process[4]



This is a versatile technique that can be used even if the electrode is not vertically oriented or when the collector and the electrode are joined by methods other than ultrasonic welding.

In this article, we discussed innovations in the collector structure and the production process for large lithium ion batteries. In Part Three, we will introduce examples of additional designs for the collector and the holding plate.

1.Japan Patent No. 3163556, U.S. Patent No. 5585207 (1994 application)
2.Japan Patent No. 5713127, U.S. Patent No. 7718312, U.S. Patent No. 8034482 (2002 application)
3.Japan Patent No. 5440663 (2001 application), U.S. Patent No. 8329338 (2002 application)
4.Japan Patent No. 5488759 (2002 application)

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