Part 03

Making History:
The Large Format Lithium Ion Battery

Further Research in the Collector Structure and in Production

In Part Two we briefly discussed development of the collector structure used in the large lithium ion batteries developed by GS Yuasa, and the production processes that provided dramatic improvements in battery yields. This article highlights subsequent developments.

1. A Production Process Suited for Automation

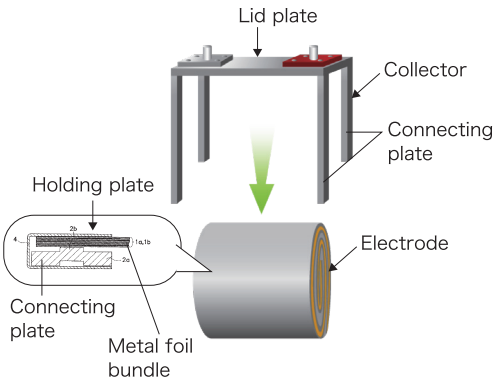
Recall from Part Two that GS Yuasa decided to first secure the lid plate and the collector together, and then join the connecting plate and the end of the electrode (metal foil bundle). When these parts were ultrasonically welded together, the holding plate served as a means for correctly positioning the connecting plate and the metal foil (●Fig. 1). Unfortunately, this process required the positioning of three parts—the connecting plate, the metal foil bundle, and the holding plate—and thus was not suitable for automation.

GS Yuasa came up two improvements that provided a production process better suited for automation, thus enabling mass production and further reducing costs. First, the process was modified so that the holding plate clamped only one end of the metal foil bundle; second, the connecting plate of the collector was arranged outside the holding plate. With these changes, only two of the three parts needed to be positioned correctly (●Fig. 2). The new production process removed the steps requiring manual work, allowing for automated assembly of the battery.

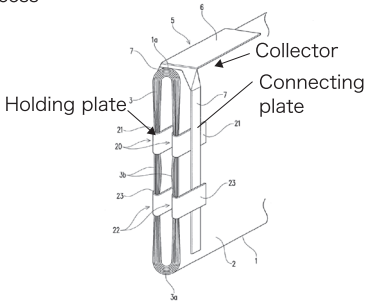
2. Simplifying the Collector Welding

Parts to be welded together are usually clamped between an oscillator (ultrasonic horn) and a receiving jig (anvil); the vibrations from the ultrasonic horn are transmitted to the parts to weld the parts together. Therefore, to weld the metal foil bundle to the connecting plate in the collector, the vibrations of the ultrasonic horn must be transmitted to the metal foil bundle and vibrate the metal foil. As shown in Fig. 2, placing the metal foil bundle inward of the connecting plate hampers the transmission of vibrations from the ultrasonic horn to the metal foil bundle. Consequently, we came up with a new collector design (●Fig. 3). This newly-designed collector has a first plate that aligns the electrode laterally and a second plate that is bent away from the first plate.

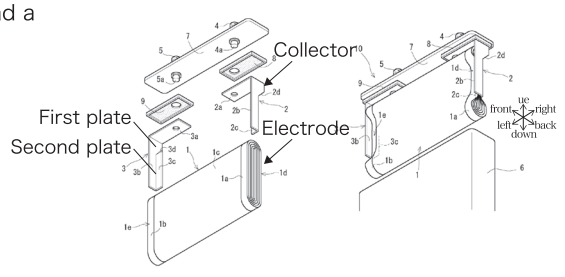
●Fig. 1 GS Yuasa's semi-automated assembly process



●Fig. 2 GS Yuasa's novel fully automated assembly process[1]



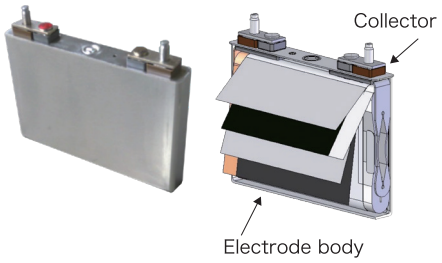
●Fig. 3 New collector design[2]



An electrode is inserted from the front in between a pair of collectors, and the first plate of the collector aligns the electrode laterally. The second plate of the collector thus supports the electrode from behind. However, the front part of the electrode is exposed and not covered by the collector. Therefore, the ultrasonic horn can be brought close to the metal foil bundle at the end of the electrode from the front without obstruction, thus simplifying the welding procedure.

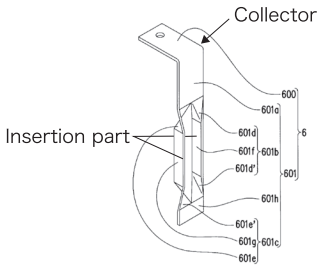
In 2011, GS Yuasa introduced the EH4 –a lithium ion battery for hybrid vehicles (●Fig. 4).

●Fig. 4 EH4 battery and its internals



You may have noticed that the EH4 collector shown in Fig. 5 is a modified version of the collector in Fig. 3. In this version of the collector, a slit is created on the plate-shaped collector; twisting each part of the plate separated by the slit inwards creates a pair of insertion parts. The metal foil bundle at the end of the electrode is separated into halves when assembling the electrode and the collector. The pair of insertion parts on the collector is inserted into the center space created in the metal foil bundle. While the insertion part of the collector is located on the inside of each half of the metal foil bundle, the outside of the metal foil bundle is exposed without being covered by the collector. Therefore, it is possible to bring the ultrasonic horn closer to the metal foil bundle from the outside without obstruction.

●Fig. 5 EH4 Collector[3]



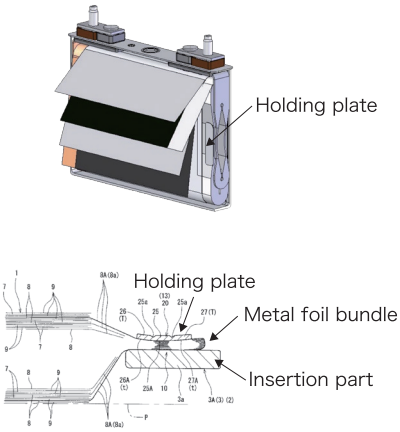
3. Avoiding Damage to the Metal Foil

A newly-designed holding plate was also introduced in the EH4 (Fig. 6).

This holding plate is square and is located outside each half of the separated metal foil bundle. The metal foil bundle is sandwiched between the center of the holding plate and the insertion part of the collector, with the center of the holding plate arranged roughly parallel to the insertion part. Although the center of the holding plate supports the metal foil, the periphery of the holding plate is inclined, gradually moving away from the metal foil. This shape reduces the risk of damage to the metal foil at the edges of the holding plate while welding. Further, if the battery is installed in a vehicle, the shape of the holding plate also improves the battery' s tolerance to the vibration produced when the vehicle is traveling.

In this article we explored the developments pertaining to the collector structure and production processes for large lithium ion batteries. In Part Four we will discuss the development of the gasket, which is an important element used for insulation in large lithium ion batteries.

●Fig. 6 Holding plate for EH4 battery[4]



1.Japan Patent No. 5796794, U.S. Patent No. 8932740 (2009 application)
2.Japan Patent No. 5716398, China Patent No. 200980121676.3 (2008 application)
3.Japan Patent No. 5717008, U.S. Patent No. 9,123,475, China Patent No. 201180005062.6 (2010 application)
4.U.S. Patent No. 9159505, European Patent No. 2565962 (2011 application)

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