Flooded Type ISS Battery with Improved High Durability and High Charge Acceptance

Shingo Araki
Energy Devices & System Business Headquarters,
Energy Devices & System Development Center,
Automotive Battery R&D Department

Toshio Shibahara
New Business Development Headquarters,
Tsukuba Research Laboratory,
Energy Devices and Materials Development Center

1 Abstract

Improved charge acceptance and durability have been required for batteries loaded on the ISS (Idling-Stop System) vehicle, because they have to supply electricity to the vehicle and accept high regenerative power. A new separator design, including a conventional PE separator and specific non-woven fabric, was adopted for the third-generation battery to improve durability to 200% compared to the second-generation ISS battery. We focused on an organic fiber with particular hydrophilic treatment as a non-woven fabric to achieve a new thinner structure and enhance battery performance.

2 Key Features

By employing a new separator design which combines a conventional separator with special non-woven fabric, the deterioration of the electrode caused by differences in electrolyte concentrations between the top and bottom of the electrode (stratification)[1] is suppressed and a third-generation battery, which improved the durability of the battery for ISS vehicles by 200% compared to the second-generation product, was successfully developed.

3 Development Background

From now, the market for ISS vehicles is expected to grow because although ISS vehicles require little in terms of changing the vehicle system, we can expect[2] it to boost fuel efficiency by 10% or so. Accordingly, we introduced the first-generation battery for ISS vehicles onto the market in 2010, since which time its sales have grown[3]. The ISS battery requires higher durability and charge acceptance than a general purpose battery, to handle the increased electricity discharge during idling stops and regenerated electric power. With this in mind, we improved its charge-acceptance performance by significantly improving the functional capability of the electrode, using positive electrode high-density active material and new carbon for the negative electrode and introduced our second-generation product to the market in 2012[4]. From now, the battery for ISS vehicles will have to be further improved to further enhance fuel efficiency. This time, we worked on a new separator design, which combines a conventional separator with non-woven fabric, together with durability improvement to develop our third-generation product.

4 Technical Content

1. Regarding stratification suppression with a new type separator design

Figure 1 shows the difference in phenomena between conventional design and a new type of separator design. In the conventional design structure, sulfate ions descend and differentiate the concentration between the top and bottom of the electrode, triggering a phenomenon called stratification. While charging the battery, sulfate ions generated at the electrode have higher specific gravity, which tends to cause them to move downward. At the same time, sulfate ions generated at and then repelled by the negative electrode again move downward, leading to a concentration-stratified layer. In the redesigned separator structure, the downward movement of sulfate ions can be hindered by bonded non-woven fabric on the surface of the negative electrode to prevent stratification.

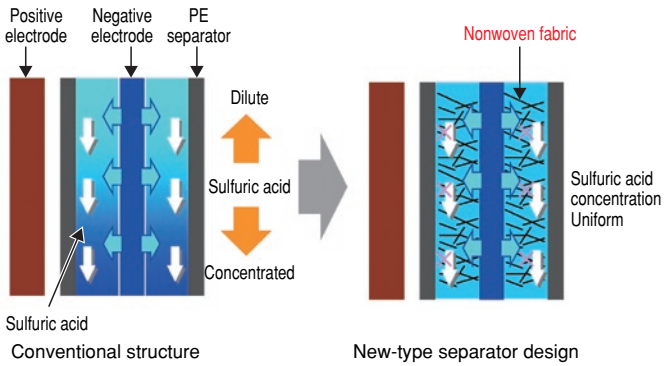


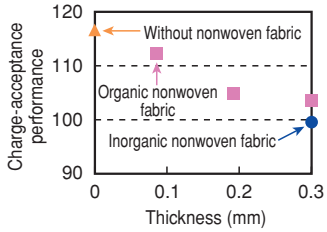
Figure 1 Stratification phenomena of conventional structure and new type separator design

2. Assessment of charge-acceptance performance

Table 1 shows a few types of non-woven fabric which we assessed. However, it is difficult to obtain any thinner inorganic non-woven fabric given the strength requirement and manufacturing process, which increases the higher internal resistance of a battery. Conversely, the thickness of organic non-woven fabrics can be altered in many ways, meaning both scope to reduce internal resistance and improve charge-acceptance performance. On this occasion, we applied hydrophilic surface treatment to organic non-woven fabrics to improve their water wettability by coating the fabric surface with fine silicon dioxide particles. Figure 2 shows the effects of various non-woven fabric types on charge-acceptance performance in the new separator design structure, which was improved by thinning organic non-woven fabrics. It is thought that this may have been attributable to easier dispersion of sulfate ions, helped by lower internal resistance due to thinner non-woven fabrics.

Table 1 Type of nonwoven fabric

	Specification (1)	Specification (2)	Specification (3)	Specification (4)
Material	Inorganic nonwoven fabric	Organic nonwoven fabric		
Thickness (mm)	0.3	0.1	0.2	0.3

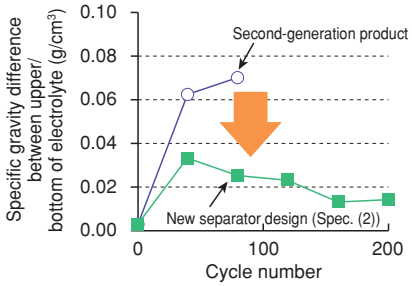


[charge-acceptance performance of inorganic nonwoven fabric as 100]

Figure 2 Influence of various nonwoven fabrics on charge-acceptance characteristics, using a new type-separator design

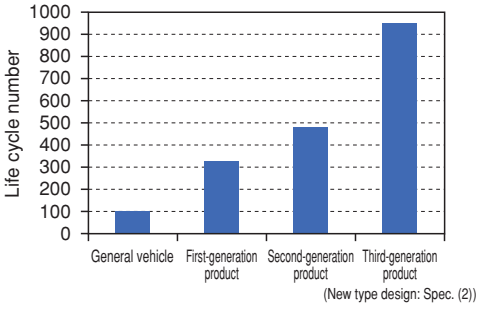
3. Assessment of durability

Durability was assessed by measuring the total number of charge-discharge cycles at a charge/discharge depth of the original battery capacity of about 10% to simulate service conditions in ISS vehicles. Figure 3 indicates the stratification level during charging/discharging cycles in the new separator design structure, which was assessed by determining differences in the specific gravity of electrolytes between upper and lower parts. Figure 4 indicates the results of a durability test in the new separator design structure. The durability of the third-generation product was improved by 200% by limiting stratification in the new separator design structure, which is comparable to approximately ten times the durability of general vehicles.



[Life cycle number of second generation product as 100]

Figure 3 Comparison of stratification degree between the first generation and new type separator during cycling



[Life cycle number of general vehicle as 100]

Figure 4 Durability improvement by new type separator design

5 Future Business Development

Globalization of the flooded-type ISS battery with improved high durability and high charge acceptance

【References】

1) SAUER D U, et al., "Optimum battery design for applications in photovoltaic systems. Theoretical considerations", J Power Sources VOL. 95 NO. 1/2; pp. 130-134; (2001)
2) David Alexander, et al. "Stop-Start Vehicles Micro Hybrid Technologies, Batteries, and Ultra-capacitors: Global Market Analysis and Forecasts (2012)", Pike research
3) Keiichi Wada, et al.: Battery for ISS (Idling-Stop System) Vehicle, Shin-Kobe Technical Report, No. 20, p. 17 (2010)
4) Koji Otsu, et al.: ISS Lead-Acid Battery 'M-42' for Light Cars, Shin-Kobe Technical Report, No. 22, pp. 15-18 (2012)

【Reference Patents】

Patent Number 5621841, Patent Number 5598532, Patent Number 5126454, Patent Number 5500315