Analysis of Water Consumption Mechanism of Lead Acid Batteries under Idling Stop System Operational Conditions

Daisuke Hosaka

New Battery R&D Dept.,
Advanced Battery & System Development Center,
Energy Storage Business Strategy Sector,
Energy Storage Business Headquarters

1 Abstract

A vehicle equipped with idling stop system (ISS) has a function to stop its engine operation while stopping at traffic lights etc. A lead acid battery for an ISS vehicle is required to demonstrate a high charge acceptance for the improvement of fuel efficiency. Low water consumption (WC) is also required practically to eliminate the frequency of a water refill from a viewpoint of a maintenance-free battery. However, WC of a lead acid battery with a high charge acceptance tends to increase under the conventional over charge tests' conditions. In this report, WC behavior during a cycle test simulating ISS operational conditions (ISS cycles) is investigated by means of a real-time gas analysis. No simple correlation of a linear relationship appears between the two tests concerning the WC. No significant WC difference between high and low charge acceptance batteries was demonstrated under the ISS operational and these experimental conditions.

2 Characteristics of the New Technology

- Real-time analysis of gases generated due to water electrolysis during charging.
- Clarification of the mechanism of water consumption during the ISS cycle.

3 Background of the Development

ISS vehicles can improve fuel efficiency over existing gasoline vehicles with little change to the control system. Due to their excellent cost performance, global production is expected to continue to grow from now on. Many ISS vehicles are equipped with a function called regenerative charging that generates electricity from kinetic energy during deceleration and stores the energy in the battery. Charging is normally performed by consuming fuel to run a generator, whereas regenerative charging consumes no fuel to generate electricity and charge the battery. Therefore, the greater the charge acceptance and the larger the regenerative charging capacity, the more the fuel consumption can be reduced. For this reason, from the viewpoint of improving fuel efficiency, batteries for ISS vehicles need to have high charge acceptance. On the other hand, low water consumption is demanded from the standpoint of maintenance-free operation. But the same overcharge testing that has been being applied to lead acid batteries for conventional non ISS vehicles is still used as the method to evaluate the water consumption characteristics of the lead acid batteries for ISS vehicles. In general, lead acid batteries with high charge acceptance tend to show higher water consumption under overcharge testing conditions[1), 2)], but sufficient knowledge has not been obtained about the water consumption behavior during the charge and discharge cycles for ISS.

4 Technical Details

Figure 1 shows the gas analysis equipment used in this study[3)]. The equipment consists of a hydrogen sensor, a gas flow sensor and an oxygen sensor. The water consumption behavior was analyzed by introducing the gases generated from the lead acid battery due to the electrolysis of water during the overcharge test and ISS cycle into the gas analysis equipment to analyze the gas generation behavior in real time. The test temperature was set to 60 °C in the assumption that the engine compartment where lead acid battery is located is hot. A total of 10 specifications of single-cell lead acid batteries with different charge acceptance were fabricated and evaluated for this test.

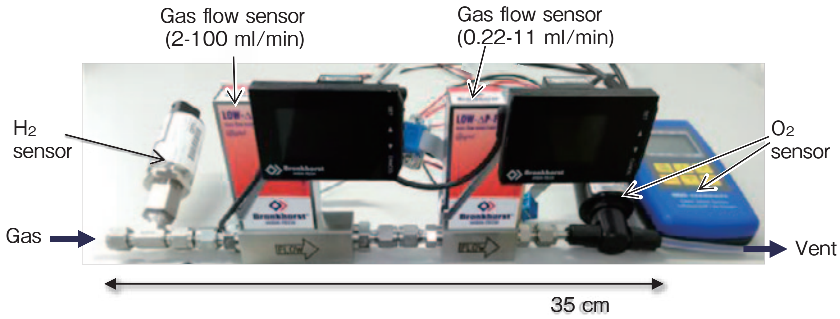

Figure 1 Gas analysis equipment

Figure 2 shows a comparison of the rates of water consumption during the overcharge test and the ISS cycle. The flow rates of gas generated during the test were used as an indicator of the water consumption rates. As shown on the horizontal axis, each water consumption rate during the overcharge test varied significantly according to the battery specifications. On the other hand, each water consumption rate during the ISS cycle did not show significant differences when the battery specifications changed, as shown on the vertical axis. This indicates that batteries that have a high water consumption rate in the overcharge testing that has been being applied to lead acid batteries for conventional non ISS vehicles will not necessarily have a similarly high rate of water consumption in the ISS usage environment[4]. This difference is due to the fact that water electrolysis occurs as the main reaction in the overcharge test because the lead acid battery is fully charged, whereas the charging reaction of a lead acid battery occurs as the main reaction during the ISS cycle because the battery is not fully charged, and water electrolysis occurs as a side reaction[5]. This suggests that a method of evaluating water consumption for lead acid batteries for ISS vehicles is required to replace the conventional water consumption evaluation tests.

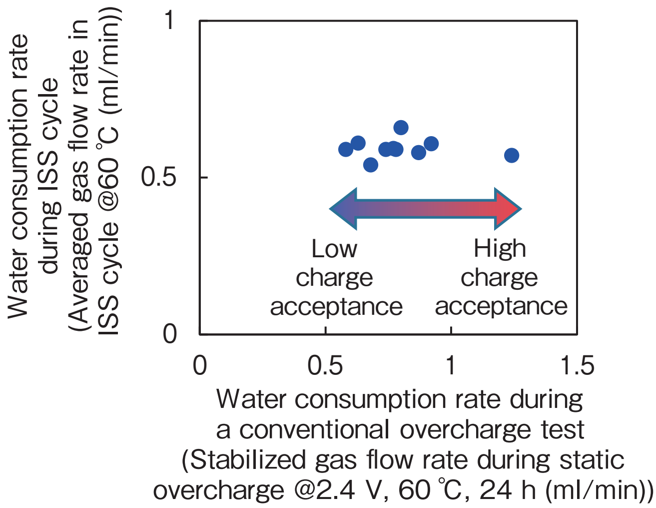

Figure 2 Comparison of water consumption rates during
a conventional overcharge test and ISS cycle

5 Future Business Development

・Promoting standardization of new water consumption evaluation tests for lead acid batteries for ISS vehicles
・Application to improve the characteristics of lead acid batteries for ISS vehicles

【References】
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3) D. Hosaka : Presentation at 8th AABC Europe, January 2018, Mainz, Germany
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【Related patent】
Japanese unexamined patent 2019-79778 WO2019/082766