Development of a Traction Circuit for a Battery-powered and AC-fed Hybrid EMU

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1. Overview of Battery-Powered and AC-Fed Hybrid EMU

The battery-powered and AC-fed hybrid EMU (Electric Multiple Unit) can reduce environmental load and maintenance cost in non-electrified line sections by replacing aged diesel trains. This hybrid vehicle has no engine and, while running in AC-electrified sections, its motors are driven by electric power from overhead contact lines and its on-board batteries are recharged. In non-electrified sections, the vehicle is powered by batteries.

2. Traction Circuit Employed in Test Vehicles

The test train of the battery-powered and AC-fed hybrid EMU (Fig.1) was jointly developed with the Kyushu Railway Company and others. It was completed in March 2013. The first important point of this traction circuit technology that we have developed and introduced to the test train is its direct battery connecting configuration (Fig.2). Since the charging by overhead contact lines is controlled by an existing Pulse Width Modulation rectifier in this configuration, an additional power converter for charging and discharging is unnecessary. Thus the size and cost of the traction circuit can be reduced. The second important point concerns the arrangement of the fuses for the high-voltage lithium-ion battery over 1300 V. In this development project, the traction circuit has been designed to be compact by using small-sized fuses, thus minimizing the use of large-sized circuit breakers and preventing large-scale short circuit failures.

3. Results of Running Tests and Future Efforts

By conducting running tests over three seasons in spring, summer and winter of 2013, we have verified that the new train is fully equipped with such basic performance capabilities as battery-driven operations and rapid charging. Figure 3 shows the results of typical battery endurance tests. After running 30.4 km with battery power only, we could fully charge the battery by executing an 8-minute rapid charge. Furthermore, verification tests on the risks of battery temperature increase have been conducted and it was confirmed that, even in summer time, the battery temperatures can be kept in a sufficiently safe range by forced air-cooling. We also confirmed that the overhead contact line is not overheated even when the battery is under rapid charging.

In the near future, we are going to improve our system and tackle the challenges found in the test train, particularly reducing the charging time at low temperature and increasing battery capacity. We hope this future work will contribute to further the utilization and acceptance of the hybrid EMU.

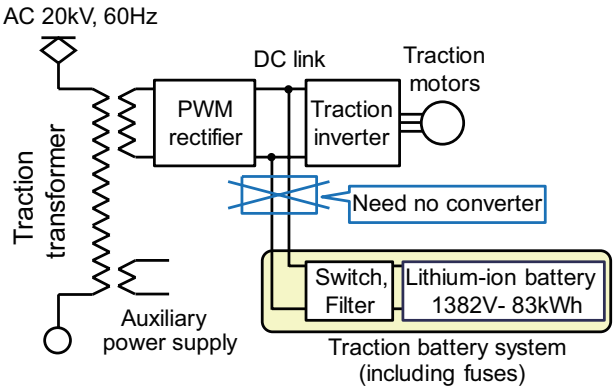

Fig.2 Configuration of the developed traction circuit

Fig.1 Battery-powered and AC-fed Hybrid EMU (test train)

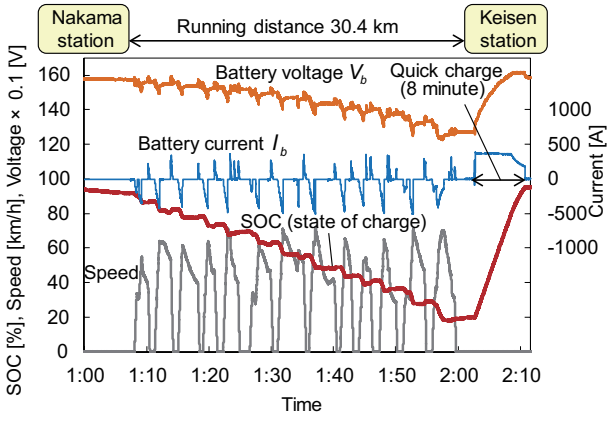

Fig.3 An example of the results of battery endurance tests