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A Study on a variable battery connection and quick charging behaviors

-A report of simulations and experimental results -

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In this paper, we will examine the modeling for calculating and predicting the charging behavior of the storage battery. The basic process of quick charging is divided into two stages. In the initial stage of charging, constant current charging is performed by charging with the maximum current that can be supplied by the charger. As constant current charging progresses, the voltage applied to the storage battery to allow constant current to flow rises, eventually reaching the maximum applied voltage (withstand voltage of the battery). From this point, the process shifts to the second charging process, constant voltage charging. When the voltage is maintained constant, the current value gradually decreases, and charging is completed when the current value falls below the predetermined minimum current value.

The constant current charging is expressed by Eq.1 and the constant voltage charging is expressed by Eq.2

$$V = (k_1 i)t + (Ri + k_0) \quad (1)$$

$$i_{(t)} = i_{\max} \exp(-\frac{k_1}{R} t) \quad (2)$$

Figure 1 shows the simulation results when the batteries connected in parallel are charged with a quick charger of up to 62A. The Constant current charging is performed until around 3600 seconds in the first half, and after the cell voltage reaches 4.0V (unit voltage 96V), the chargng mode is switched to the constant voltage charging and it can be seen that the current is decreasing exponentially.

Figure 2 summarize the comparison of the connection conditions examined and the charging behavior depending on the performance of the charger. It was found that the difference in charging efficiency due to series / parallel switching of the circuit is large in the case of a current of about 60 A, and the charging time can be shortened by parallel connection. (When charging 6kWh, the time is reduced to about 56% in 61 minutes in parallel and 34 minutes in series.) On the other hand, even if a large current charger is used to further reduce the charging time, the effect is limited. (47% time reduction from 61min to 29 minutes to charge 6kWh).

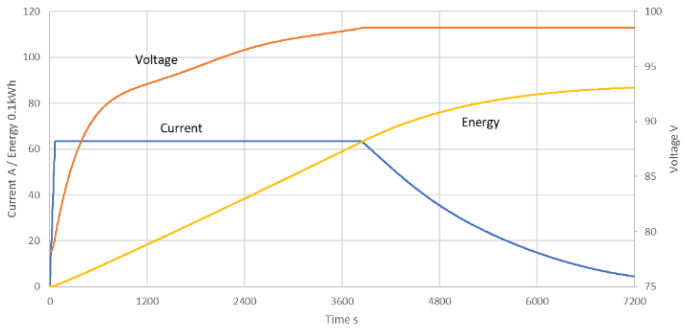

Fig.1 Simulation results（parallel 2units, 62A charge）

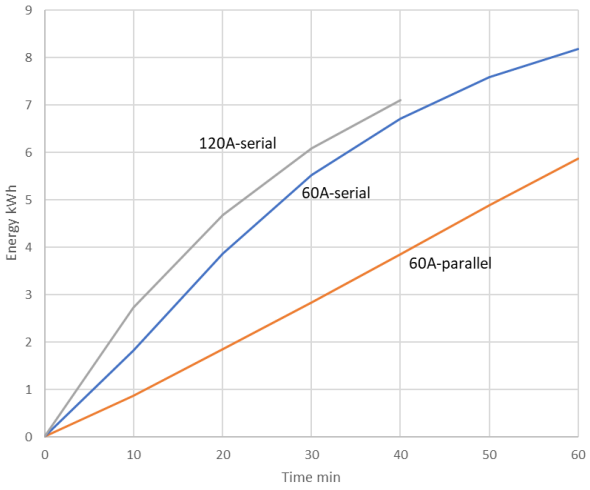

Fig.2 Comparison of charging parallel/serial and max. current