Development of a Long-Life Nickel Metal -Hydride Battery for Hybrid Electric Vehicles

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INTRODUCTON

For Hybrid Electric Vehicles (HEV) use, Ni-MH batteries are strongly required to yield high output power at the start-up and acceleration of an HEV throughout its life time for long years. In this sense, a Ni-MH battery optimized for consumer use cannot always meet HEV requirements.

In this work, we investigated the deterioration mechanism of the output power of a Ni-MH battery for HEV use by analyzing its positive and negative electrodes and separator after cycles. Based on the obtained results, cycle life in terms of output power has been improved.

EXPERIMENTAL

Sealed cylindrical D-size cells with a typical capacity of 6.5Ah were prepared, where a sintered nickel hydroxide electrode coprecipitated with Co and Zn for positive electrode, a Mm-Ni-Co-Mn-Al hydrogen-absorbing alloy electrode for negative electrode and a polyolefin separator were assembled.

Life tests were conducted under an accelerated condition at 45 deg.C simulating an actual HEV driving pattern. The output power was measured at every 20k miles of the corresponding distance under the test condition until the output power of the test cells decreased by 30% of the initial value. The DC resistances of the positive and negative electrodes were also measured by inserting an Hg/HgO reference electrode into the cell in order to clarify the contribution of each electrode. The positive and negative electrodes and the separator were chemically analyzed, and the separator was also analyzed with XRD in order to determine the deposits on it.

RESULTS AND DISCUSSION

Change in the output power of the test cell under the HEV driving condition is shown in Fig.1. The maximum discharge current decreased after cycles to 73% of the initial value at 90k miles. Accordingly, the cell resistance increased by 0.65 mohm from the initial state at 90k miles as shown in Fig.2. The DC-resistance measurement using a reference electrode indicated that 63% of the increase in the cell resistance was the contribution from the positive electrode. The contribution from the negative electrode was relatively small.

Chemical analysis of the electrodes showed that the decrease in the output power has a good correlation with the increase in the aluminum content and the decrease in the zinc content in the positive electrode. The increase in the oxygen content and the decrease in the aluminum and manganese content in the negative electrode have also a good correlation. XRD analysis of the separator indicated the existence of a compound comprising manganese and zinc on the separator. As it is reported and well-known that the swelling of nickel hydroxide electrode due to the formation of gamma-nickel oxyhydroxide during charge-discharge cycles resulting in the decrease in dischargeability is larger for less zinc content in a sintered nickel hydroxide electrode[1], the deterioration of the output power of the positive electrode may be caused by the dissolution of zinc from the positive electrode. The decrease in the zinc content in the positive electrode may be enhanced by the formation of the zinc-manganese compound on the separator. These results mean that the dissolution of the elements such as manganese of the negative electrode affects the increase in the DC-resistance of the positive electrode, although the effect of the aluminum in the positive electrode is not clear yet.

Based on the above observations, the composition of the hydrogen-absorbing alloy for the negative electrode was improved by decreasing the manganese content. The test cell using the improved alloy with less manganese exhibits better cycle characteristics in terms of its output power as shown in Fig.3.

REFERENCES

1) Masahiko Oshitani, Takashi Takayama, Koichiro Takashima, Shigeo Tsuji, *J. Appl. Electrochem.*, **16**(1986)403.

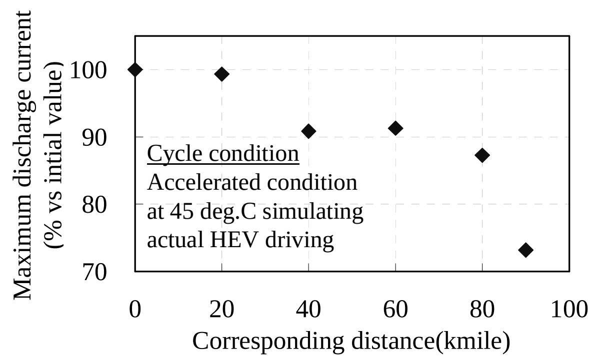

Fig.1 Change in the output power during HEV driving pattern cycles.

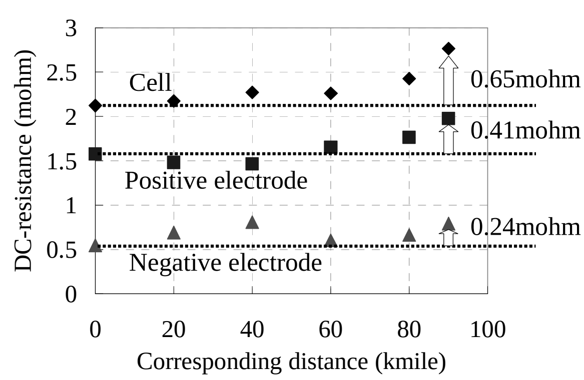

Fig. 2. DC-resistance of the cell and the positive and negative electrode during cycles.

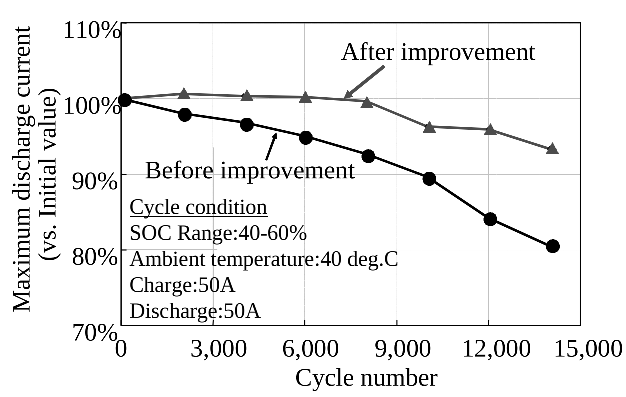

Fig. 3. Cycle characteristics of the improved cell using the optimized hydrogen-absorbing alloy with less Mn content.