APPLICATION**NOTE**

Measuring Operation Performance of NiMH D-Cell Using *VariPhi*™ Sensor

Isothermal Calorimetry for Advanced Battery Testing

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Introduction

Nickel-Metal Hydride battery (NiMH) is a type of rechargeable battery. It is similar to the nickel-cadmium battery (NiCd), but has much higher energy density and capacity. Because it does not use the toxic cadmium, it also has less impact on environment. NiMH batteries are readily available in different sizes. They are extensively used in consumer electronics.

NiMH battery will generate or adsorb heat during charging or discharging. It is important to know the amount of heat involved in order to understand the battery chemistry and improve its performance and lifetime. Thermal Analysis and Calorimetry have been used to study battery materials and full cells. Calorimetry, in particular isothermal Calorimetry, in conjunction with charging/discharging in normal and exaggerated conditions is critical for thermal management studies and to estimate long-term effects. This application note will detail the application of isothermal calorimetry to measure the operation performance of NiMH D-cell.

Instrumentation

The Calorimetry used in this note was the NETZSCH ARC® 254 system (Figure 1) equipped with the battery cycler interface kit and the D-Cell *VariPhi*™ sensor. The ARC® 254 is an accelerating rate calorimeter designed specifically for adiabatic operation. However, by incorporating the *VariPhi*™ sensor, the user is able to run true isothermal Calorimetry experiments.

Using the patented *VariPhi*™ technology, one can run the ARC to get isothermal and heat capacity data. Furthermore isothermal calorimeters are generally not designed to handle the potential risk of thermal runaway and explosion

1 NETZSCH ARC® 254

but using the *VariPhi*™ and the ARC together, one has the advantage of running the isothermal test in a robust ARC calorimeter. This is a unique feature of the NETZSCH ARC product.

The *VariPhi*™ technology has been introduced over 5 years ago and is described in several publications. The development of the D-Cell sensor assembly is recent and works with existing *VariPhi*™ systems. A photo of the sensor is shown in Figure 2.

2 D-cell *VariPhi*™ 3D sensor

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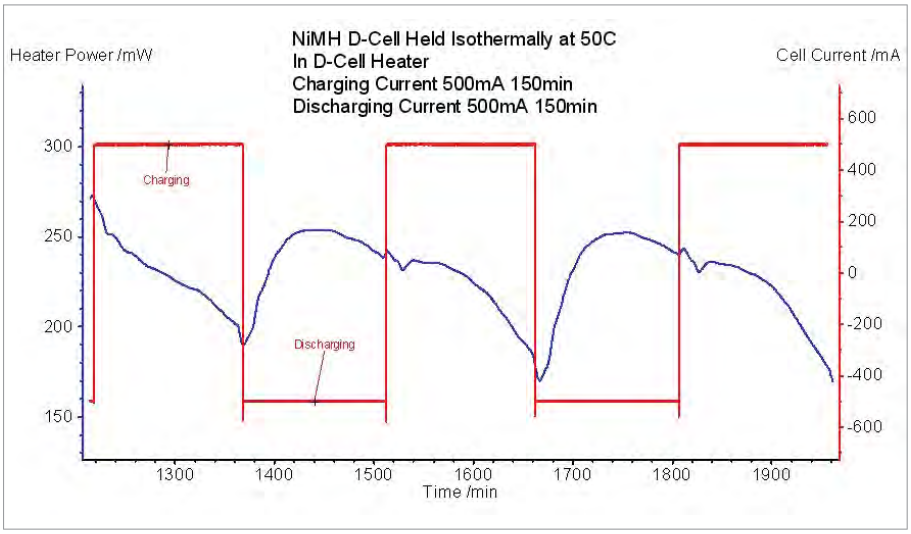
Results

One test was conducted using a commercially available NiMH D-Cell to gauge the performance of the cell. The result of the heater power vs. time is shown in Figure 3. In this test, the cell was held constant at 50°C while the cell was being charged and discharged at 500 mA. The battery was charged/discharged three times. It can be seen that the heater power decreased with the progress of charging, while during discharging, the heater power increased first and then decreased.

The sample power is just the inverse of the heater power in order to keep the isothermal condition. For example, when the current is decreasing, the rate of the endothermic reaction within the cell will also decrease which will lead to a decrease in the heater power needed to keep the battery at isothermal temperature.



3 D-cell heater power versus time for an isothermal battery cycling test at 50°C

Conclusion

Battery cycling inside a calorimeter can provide insight into the underlying phenomena occurring in the cell. Because this unique isothermal system is built into a robust ARC 254® calorimeter, it is quite possible to perform isothermal cycling tests at temperatures close to or even beyond the stated operating temperature to get a better understanding how the cell will behave in a variety of conditions. For large cells, this could conceivably lead to power output which outpaces the cooling capability of the calorimeter. In such cases, thermal runaway and explosion are likely to occur so testing must always be done at a level which is meaningful and also safe. The unique combination of adiabatic and isothermal testing in a single unit provides the user with the necessary flexibility and safety to run a comprehensive testing program.

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