better chemistry – faster

APPLICATION NOTE:

BATTERY SPECIFIC HEAT DETERMINATION

Basic Principle

Batteries generate heat when they are used – for example during charging or discharging. This leads to a rise in temperature which can be measured but this this does not provide a direct measure of the amount energy - which is important as it is being wasted as heat. This energy information can however be easily calculated from the temperature data if the mean specific heat of the battery (or pack) is known:

$$Q = m\ cp\ \Delta T \qquad (1)$$

where Q is the heat (J) generated by the battery, m (g) is the battery mass, Cp (J/g K) the average battery specific heat, and ΔT (K) the temperature rise measured.

Equation (1) is true if the temperature rise is measured when no heat is lost to the environment (ie all the energy is realised as a temperature rise in the battery). This ideal scenario can be realised if the charging or discharging is performed with the battery placed inside an adiabatic calorimeter, where heat loss is prevented as the test sample heats up. Therefore, the temperature rise measured adiabatically can be used to back out the heat (energy) loss if Cp of the battery unit is available.

Batteries are complex objects and the Cp is rarely known. Fortunately, this can also be measured in an adiabatic calorimeter again using equation (1). In this case, the battery is purposely heated at a known rate q (in W = J/s) and the resulting temperature rise is recorded. So Q can now be calculated:

$$Q = qt$$

where t (s) is the time over which q is applied in the test and leads to a rise ΔT (K) in the battery. If the battery weight, m (g) is also known then the Cp can easily be calculated from:

$$mCp = Q/\Delta T$$

or

$$Cp = Q/ m\,\Delta T$$

The BTC automatically reports mCp (J/K) on the computer screen so simply dividing the figure by mass gives the Cp (J/gK).

Illustration with known Sample

To demonstrate the method, a sample of known Cp was tested in the BTC so that the accuracy could be checked. The results from the live screen are shown below, where the sample is first stabilised at 40°C and then heating is commenced. At the end of the heating phase (selected by the user), the mCp is reported on the screen in blue – in this case 222.1 J/K.

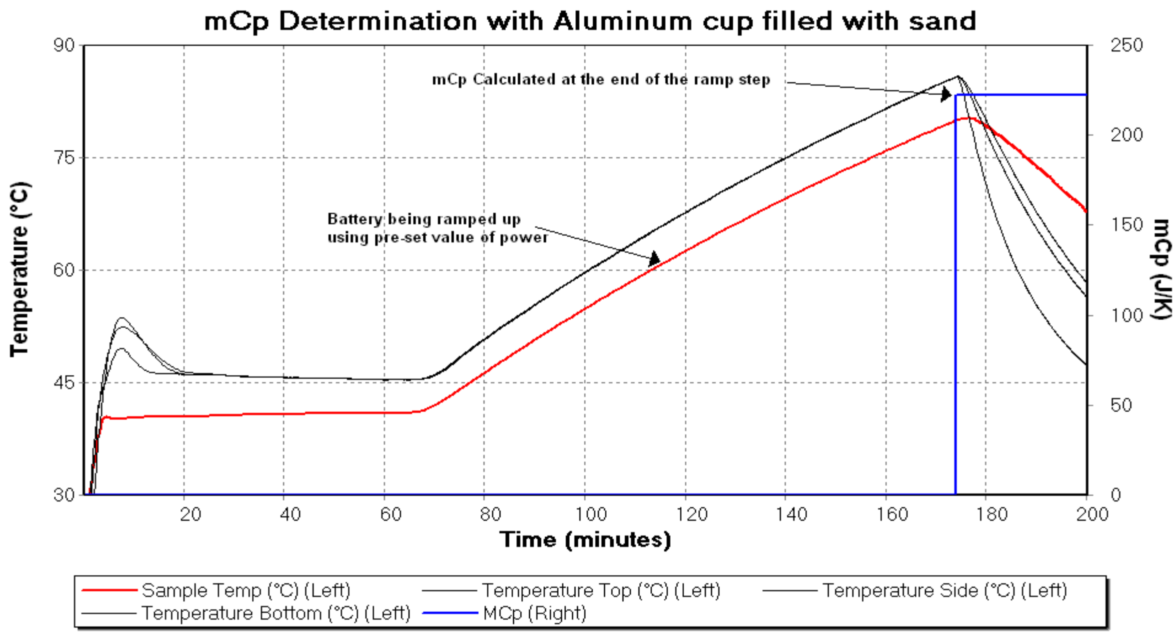

Figure 1 Data screen from adiabatic test to measure battery Cp

The total mass of the sample was 239g, hence:

$$Cp = 222.1/238 \text{ J/g K}$$
$$= 0.92 \text{ J/g K}$$

The sample was in fact sand (104.7g) placed in an aluminium container (135.2g), which has an average theoretical Cp of 0.88 J/gK. This is within 5% of the experimental answer without any special precautions to make it more accurate.

Application to real batteries

Using the procedure illustrated above, the Cp of a protype 8Ah battery cell (reference KB-38) with was determined.

The data derived from the BTC test is shown below which shows that the mCp value when the test was terminated was 239.6 J/K. The mass of the battery was 177.7g, giving a specific heat of 1.34 J/gK.

A second battery from the same stock, gave a Cp value 1.32 J/gK. Two more similar batteries cells gave a Cp of 1.37 - 1.40 J/gK.

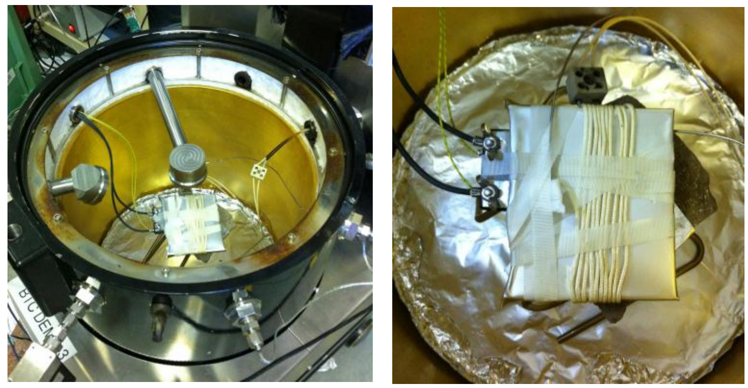

Figure 2 Protype 8Ah battery cell ready for testing inside a BTC