APPLICATION NOTE:

THERMAL DUTY DETERMINATION DURING BATTERY CHARGING/DISCHARGING, USING ISO-BTC

Battery Cooling Specification

Batteries become hot and can potentially result in thermal runaway if the temperature control is not maintained. Heat is generated quite naturally as charging and discharging of batteries takes place and especially during fast discharge of Li-ion and batteries, large amounts of heat can be produced.

Design of cooling systems requires a knowledge of the heat output at different rates of discharge and different ambient temperature. This application note describes how this can be measured while batteries are charged and discharged at different rates to provide the specification of a thermal management system.

Power Management Data

The power (ie heat output rate) changes inside a battery and the actually cooling or heating duty which a power management system has to provide, can be measured directly with an isothermal battery testing calorimeter (iso-BTC).

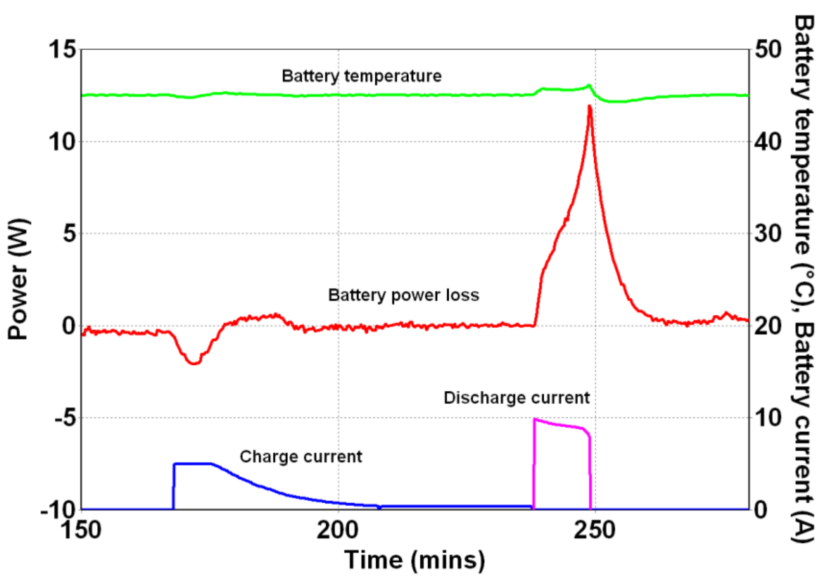

Figure 1: Power Loss (heat output) from Battery during Charge and discharge cycles

Battery power loss (ie heat wasted) is shown in figure 1, for a 3-cell Li-ion battery, charged at 5A and then discharged at 10A while the battery temperature is held constant at 45C. When the battery is charged, the battery becomes colder (a very small temperature depression is visible) and iso-BTC provides heat to the battery; when the battery is discharged, temperature starts to rise (quite clearly) hence the iso-BTC must remove energy. A peak cooling rate of around 12W is recorded.

If the battery is discharged at different rates, then the power loss from the battery will of course change. The comparative powers during discharging at 10 A and 20A, are shown in figure 2 below.

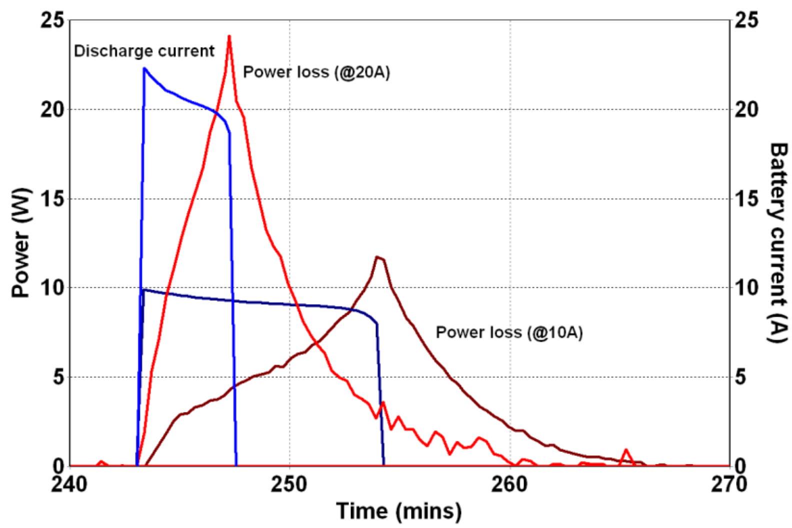

Figure 2: Comparison of battery power loss (heat generation) at different discharge rates

Basic Principle: isothermal calorimetry

The objective of the iso-BTC is to measure the amount of energy which is being generated while holding the battery temperature constant, thus performing the battery management task. Typically, the battery or pack is integrated with a cycler so that different charging/discharging routines can be programmed.

The operating principle of the iso-BTC is well established for chemical reactions and HEL has supplied hundreds of commercial calorimeters which operate isothermally under extreme conditions of temperature and pressure. The operation requires two opposing controls:

- Cooling, at a constant and fixed rate. This must be greater than the maximum heat likely to be generated by the battery during cycling.
- Thermal control (power input) – this counter- acts the effect of cooling and is adjusted automatically so as to hold the battery at the specified temperature.

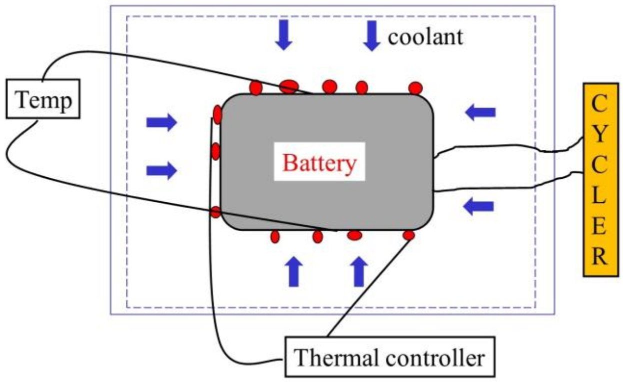

Figure 3 Working principe of iso-BTC

When the test battery is set up, before charging/discharging is commenced, its temperature is stabilised by applying the necessary power, sometimes called a base-line. When cycling commences, the power compensation systems responds to small changes in temperature that are caused: if the temperature falls (typically during charging), it adds more heat (to keep the temperature constant); conversely, when the temperature rises (during discharge), it reduces the heat addition (again to keep temperature constant. The increase and decrease in heat input are exactly equal to the energy changes taking place in the battery: it is precisely what a battery management system would need to do.

This is determined on line and reported by the iso-BTC.

Figure 4: Set up of iso-BTC