Thermal Management
of EV Batteries

Thermal Management and the Application of Calorimetry
Summary Information (Simple Example)

The Accelerating Rate Calorimeter is a versatile calorimeter that has applications in all areas of lithium battery studies – at cell, module or pack level, to aid battery development, to understand battery safety (in use and under abuse conditions and to evaluate battery performance (lifecycle, efficiency and performance).

In the latter area, where automotive applications need information on Thermal Management, the heat released from batteries under conditions of fast discharge or driving simulation cycle must be simulated. The data obtained can then be applied to Thermal Management. To do quantitative work in this area the THT EV Accelerating Rate Calorimeter may be used with options that would be necessary for determination of specific heat capacity and surface area thermal distribution measurement. (Ie the CP and MultiPoint options). IN addition to provide the discharge/charge requirement the battery must be connected to a EV/Hybrid Battery Test System or dSpace unit configured with programmable power supply /discharge units.

Illustrated here is an example with a smaller battery pack where options have been used and appropriate data obtained. The discharge is a simple single low power discharge again for illustration of the technique.

Determination of specific heat capacity

Initially the specific heat capacity must be available and here its determination is illustrated – then the surface area thermal distribution heat release is measured, here at the constant power discharge. For the example a pack of 12 lithium iron phosphate batteries were used, connected as shown in Figure 1.

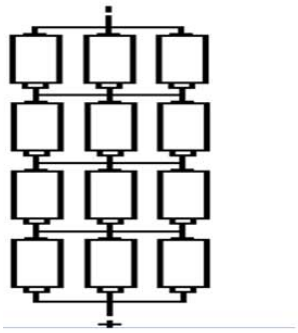


Fig 1 The Battery Pack

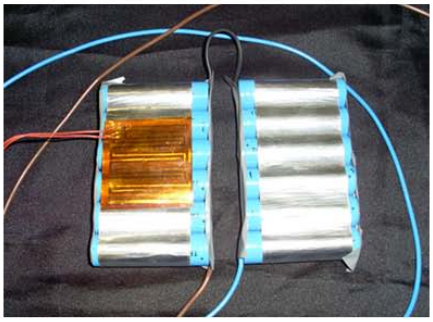


Fig 2 The Pack with Cp Heater

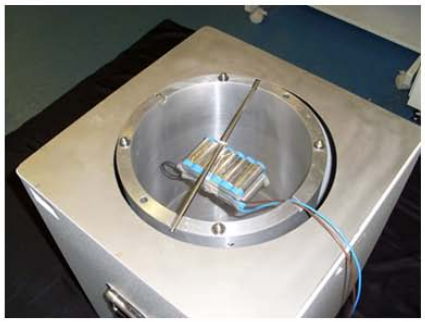


Fig 3 Pack within Calorimeter

This was carried out in the THT EV ARC using the Cp Option using the THT Ramp method. The Cp heater was used and set to supply 276mA at 10.1V (279W). The battery was of mass 617g and with an estimated Cp near 1J/gK this would give an appropriate thermal rise.

Though not needed for this test, the specific heat capacity test was carried out over the range 25-70°C to determine specific heat capacity over this temperature range.

Figs 4 and 5 show some detail of the results of this test. However the specific heat capacity is simply determined from a Wizard, shown in Fig 6, the value at 30°C is determined as 0.84J/gK

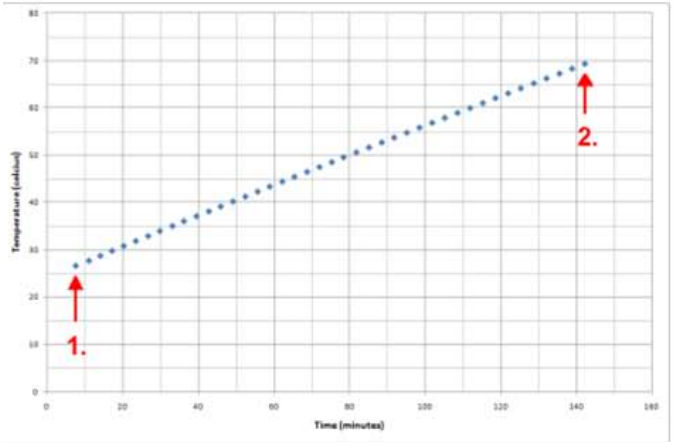


Fig 4 The Temperature Rise in the Test

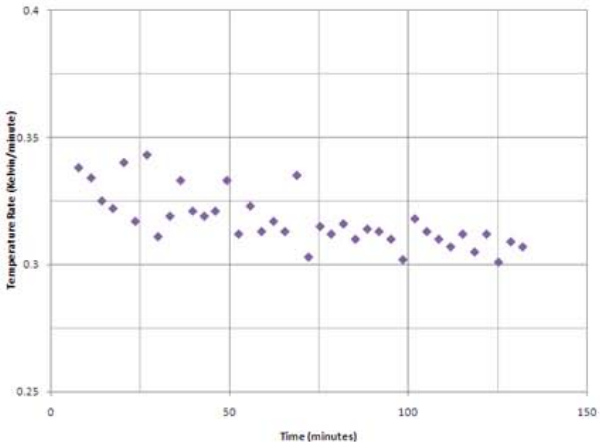


Fig 5 The Rate of Temperature Rise

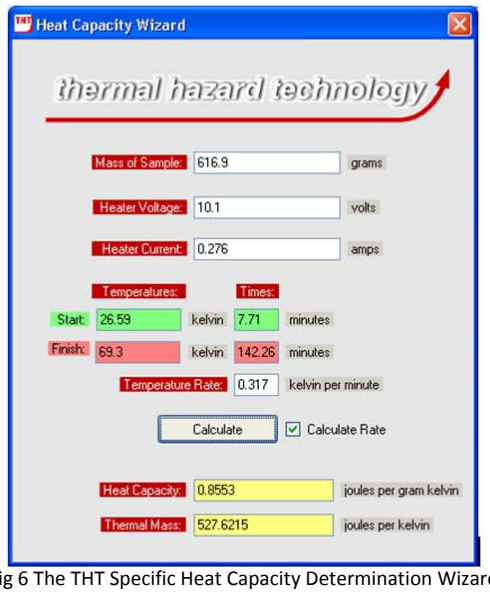
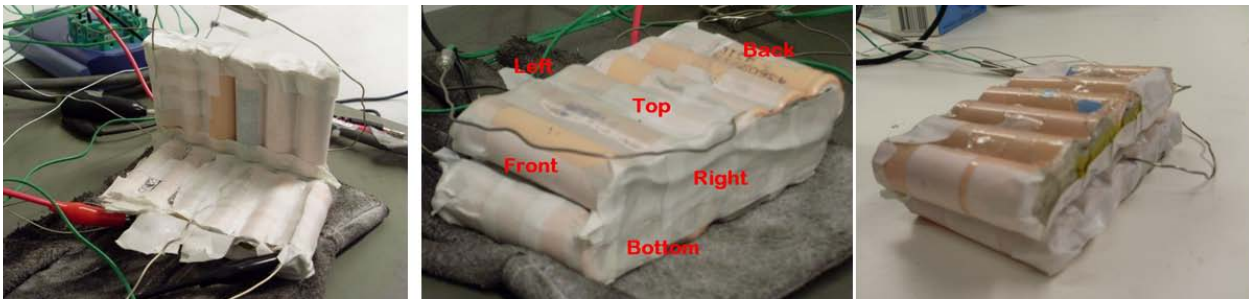


Fig 6 The THT Specific Heat Capacity Determination Wizard

This value is simply put in to the THT EV Accelerating Rate Calorimeter MultiPoint Test

MultiPoint Test for Thermal Distribution

In total the THT MultiPoint Option allows for up to 24 thermocouples to be placed on and around the cell, pack or module. For simplicity here the number was restricted. The software allows for full logging of positing against data. Figs 7, 8 and 9 illustrate the thermocouple positioning



Figs 7, 8 and 9 Thermocouple Position for MultiPoint test

In such a test, the battery pack is positioned within the calorimeter again as illustrated in Fig 3 and the system software established to initialise the test. The system is allowed to reach an isothermal temperature and when all is in thermal equilibrium and the charge/discharge carried out. In this example illustrated here, the discharge was at 5A.

A portion of the MultiPoint thermal data is shown in Fig 10. In many tests there would be charge, wait discharge or varying discharge cycles.

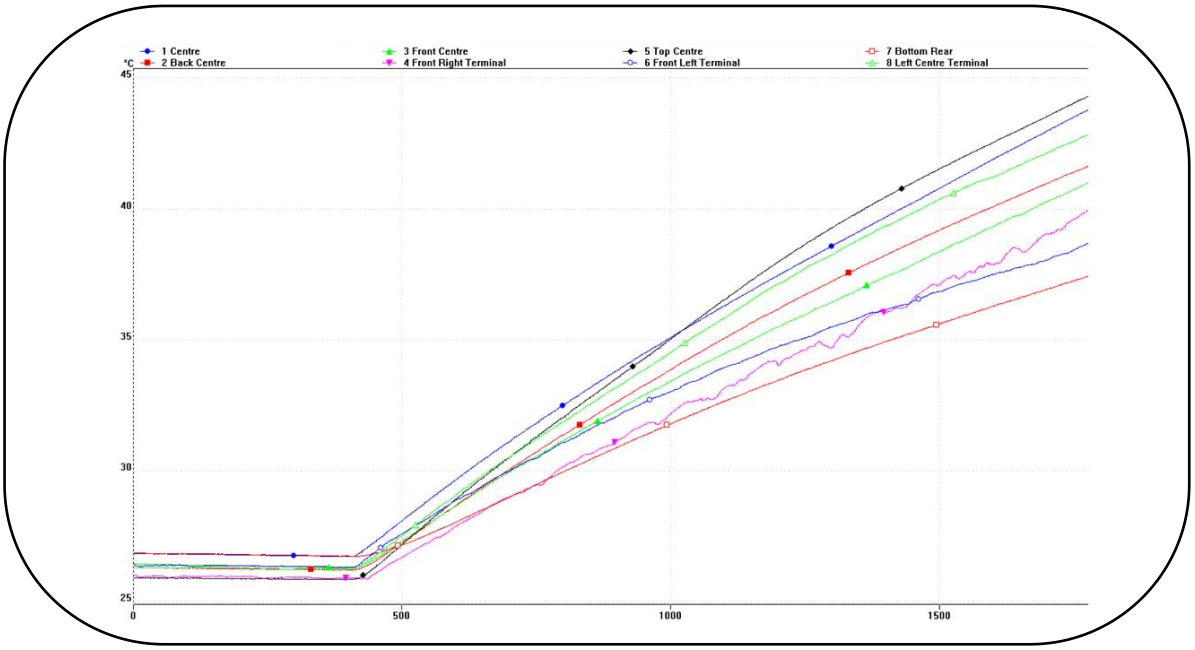


Figure 10 MultiPoint Thermal Surface Distribution on Discharge

Full analysis is available in ARCCal+ the data analysis software that supports the THT Accelerating Rate Calorimeter systems

The graph here simply shows temperature rise against time over the continuous discharge. Here it can be seen that there is variation from top to side and centre. Where heat release is most rapid the discharge was at 5A and average voltage was 12.0 Volts. ie a power discharge of 72W.

In Tabular form the data can be summarised for simplicity of understand how the data can be calculated…. Considering over a 10 minute period

Position	DegC	DegC/min	Power Watts	Heat (in 10 mins) kJ
Case	6	0.6	5.2	3.12
Terminal	10	1.0	8.7	5.20
Average	8	0.8	6.9	4.16

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Here detail is not given of the actual methodology or ARC Software – the figures below show a set up screen (illustrating a chosen cylindrical battery), Fig 11 and then data as in tabular form, Fig 12. After the test the results (with cp known) are available in Joules, Fig 13 and Watts, Fig 14.

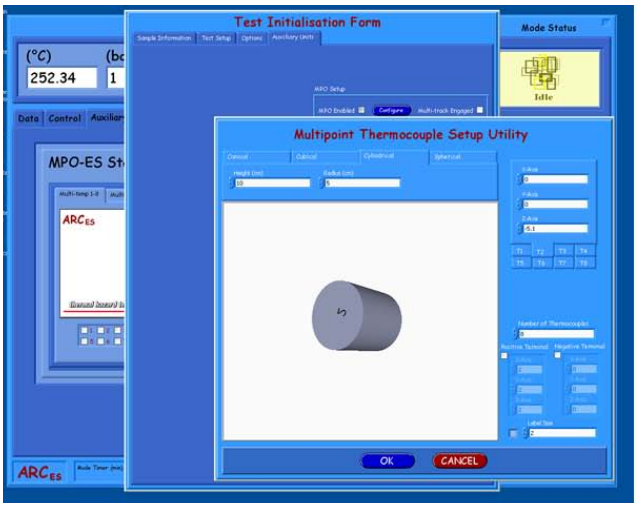

Fig 11 Software Set Up for MultiPoint

Fig 12 Screen Display during Test

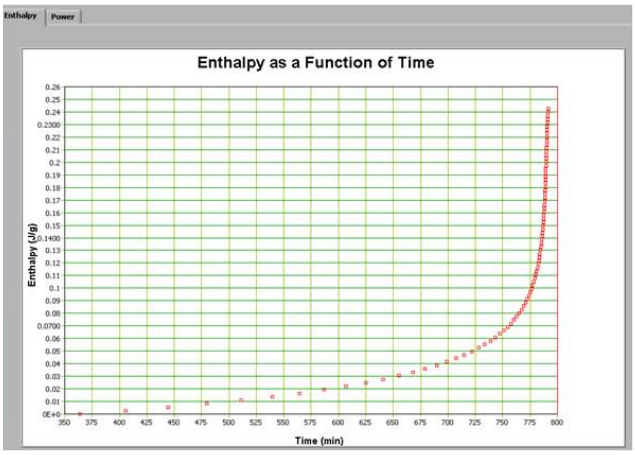

Fig 13 Enthalpy at One Point

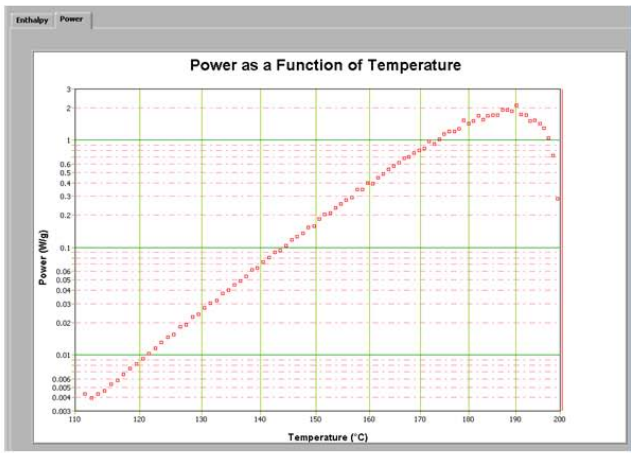

Fig 14 Power at One Point

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