Miles Summer 2016 Ridgecrest Experiment – Coolescence Analysis

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Abstract

Raw time-series data for a claimed excess heat producing experiment run during the summer of 2016 was recently made available for independent analysis. Using this data, we confirm an interpretation of excess heat follows from the assumption of a known and constant calorimeter constant, k. However, analysis of the mechanical characteristic of the calorimeter, other recorded temperature data, and behavior at the start of electrolysis suggest the assumption about k may not be justified. As a result, the conclusion of excess heat may not be valid.

Introduction

Dr. Mel Miles ran an experiment at his home in Ridgecrest, CA in July of 2016. Details of this experiment were presented at ICCF-20 and SSICCF20. Some details of the Ridgecrest experiment are contained in the presentation *"The Fleischmann-Pons Calorimetric Method And Equations"* available from: http://lenr-canr.org/acrobat/MilesMthefleisch.pdf.

Dr. Miles provided Coolescence with copies of his lab notebook, pages 85-94, which contained measurement values that were transcribed into an Excel spreadsheet at Coolescence.
With Miles' permission, we have made the spreadsheet available on the LENR-CANR site: http://lenr-canr.org/acrobat/MilesMdatafromme.pdf. This document is an analysis of that data set.

Data Set Details

The time series data set contains five measured temperatures, bath set point, cell voltage, cell current and room temp. The five measured temperatures are measured with thermistors and are assigned as follows:

- T1 - Room1 (offset value = 7.65K)
- T2 - Cell1 (offset value = -0.25K)
- T3 - Bath Temp (offset value = 0)
- T4 - Room2 (offset value = -0.12K)
- T5 - Cell2 (offset value = -0.11K)

Note: Miles considers T2 to be the "good" cell temp value. Miles considers T5 to be the result of a defective sensor. T5 was not used in his calculations.

Cell current was recorded from the galvanostat. Cell voltage measured with DVM. Per Miles, room temp was measured with a separate thermistor unit accurate to 0.1C.

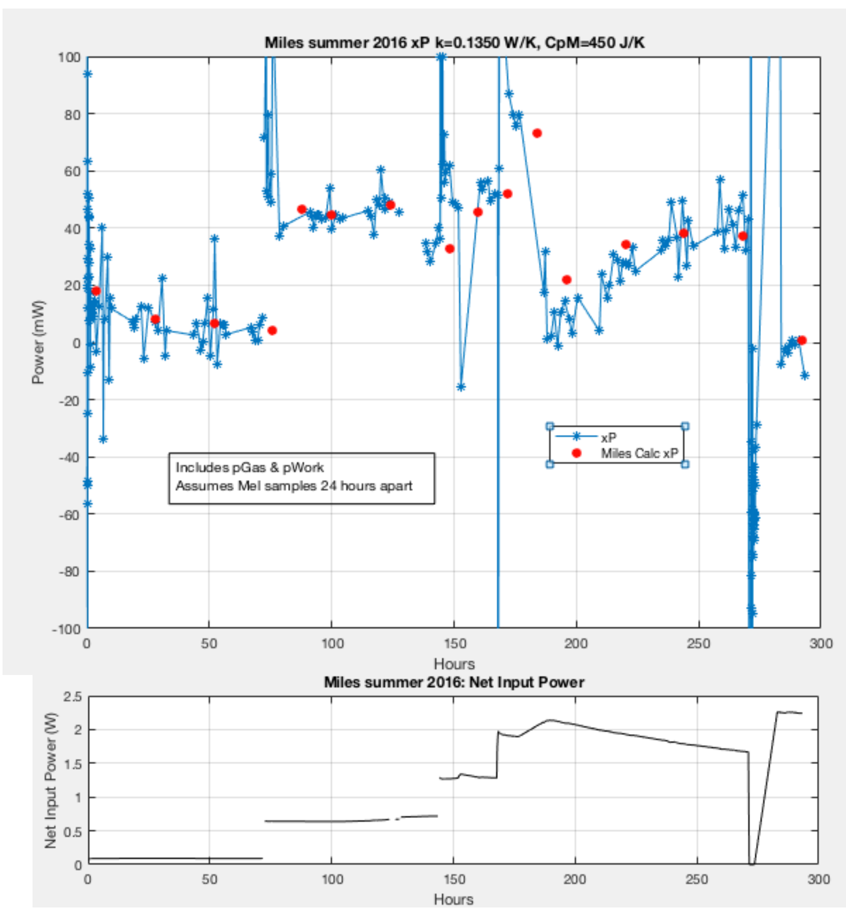
There were 276 data points recorded by hand over the 293 hour experiment. Of these 100 are at the start and during a cooling curve right before the end. The remaining 176 points are spread out across the run with a mean time between samples of 106 minutes. The sample time distribution is bi-modal with a cluster during the day centered on 80 minutes and a cluster overnight in the 600-700 minute range.

Initial calorimetric evaluation

Temperature data is evaluated using the calorimetric model outlined in Miles's earlier work, using all relevant terms (Electrolytic power, Px, CpM dT/dt, Pwork, and Pgas). Excess power (Px) is calculated as described in Miles' previously referenced presentation.

If one uses k=0.135 W/K and CpM=450 J/K, data from T2 and T3 give xP results that closely mirror those published by Miles. In the chart below, the blue Px values were calculated using the Excel spreadsheet values, and the red Px values were calculated by Miles and provided to us as a dated value (no time provided). The lack of an exact time for Miles' values presumably explains some of the skew between his values and the ones calculated from the Excel spreadsheet.

The highest Px value calculated by Miles was 75mW at an electrolytic input power of just over 2 Watts, which is roughly 3.75% of input.



Understanding calorimeter constant k

The calorimeter used in this experiment consists of two concentric copper tubes, with insulation between them. The inner copper tube holds the electrolytic cell under test, along with oil that is used as a heat transfer medium. The outer copper tube is mostly submersed in a constant temperature water bath. Note: for additional details on the construction of the calorimeter used, see the earlier referenced presentation.

The fundamental equation for the calorimeter can be written as:

$P = k\triangle T + CpM\, d\triangle T/dt$, where $\triangle T = Tcell - Tbath$.

There are several ways of calculating k. A brute force method is to hold input power constant long enough that $d\triangle T/dt$ in the equation above can be considered zero. In this case, k is equal to $P/\triangle T$. A calibration run is typically done at a number of different power levels in order to discover any non-linearities in the k value. Unexpected Px during calibration could obviously cause errors with this method, so it is often performed using a platinum cathode or a resistive heater.

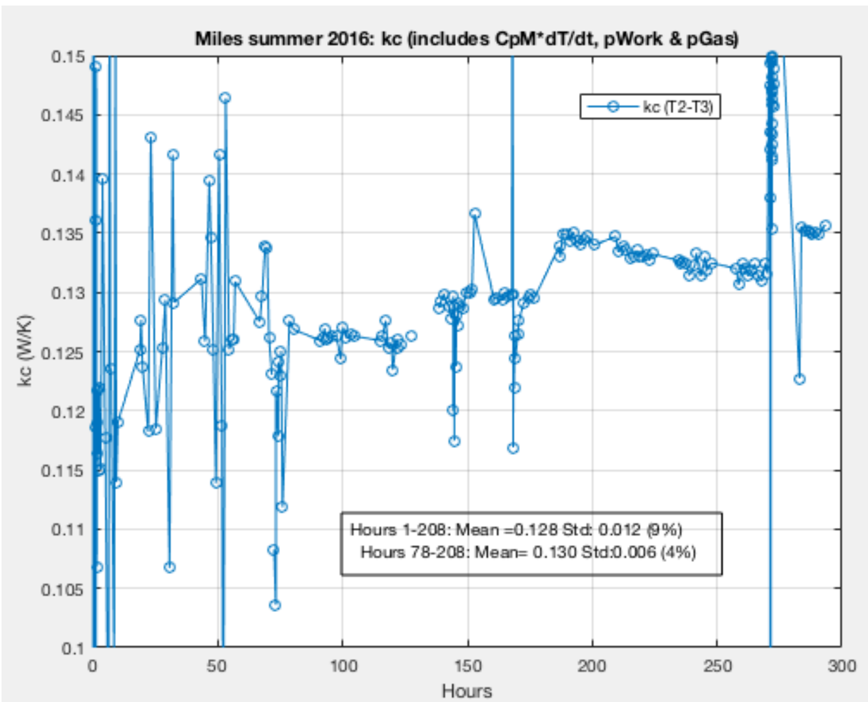
An alternative method, described in M. Fleischmann and S. Pons, *Physics Letters A*, *V*olume 176, Issues 1–2, 3 May 1993, Pages 118-129 calculates k (renamed k'c by F&P in the paper to denote the different calculation technique) by assuming Px=0 at the most conservative point in the data set. This technique requires that CpM be known or estimated in order to include the dynamic term in the equation above. This technique necessarily assumes a linear calorimeter, but linearity can be checked and appropriate error bars adopted using the brute force method.

With either method, the validity of an excess heat interpretation of the temperature data rests on assumptions about the calorimeter constant, k. It is assumed that k is constant throughout the run. In email discussion, Mel has suggested there is a "correct value" for k which is 0.135 W/K. For k to remain constant, all factors affecting k and the $\triangle T$ measured during calibration or operation would have to be constant, except for input power and any excess power.

In 2010 we pointed out there is a significant radial thermal gradient in the oil surrounding the electrolytic cell, making k sensitive to the location of the temperature probe in the radial direction. In the Miles implementation of the Cu tube calorimeter more than a third of the thermal resistance is across the oil (~3K/W in the oil vs ~4.2K/W across the insulation). An updated version of our 2010 analysis: *"Radial position sensitivity analysis for Miles Cu tube calorimeter"* is included as an appendix to this document. It shows a 1mm change in radial position of a temperature probe would result in a 3-11% change in k depending on what moves (probe or electrolytic cell) in the oil. As far as we are aware, in the Miles calorimeter the temperature probes are held in place on the electrolytic cell with a rubber band, and the electrolytic cell is not fully mechanically centered in the oil.

The chart below shows a calculation of k assuming no excess power is being produced during the run. Before hour 75 or so, the input power is low enough that △T is a small number, leading to significant noise in the resulting k value. After hour 75, the variation in the k value could be the result of excess power being produced, or uncontrolled movement of the T2 temperature probe.

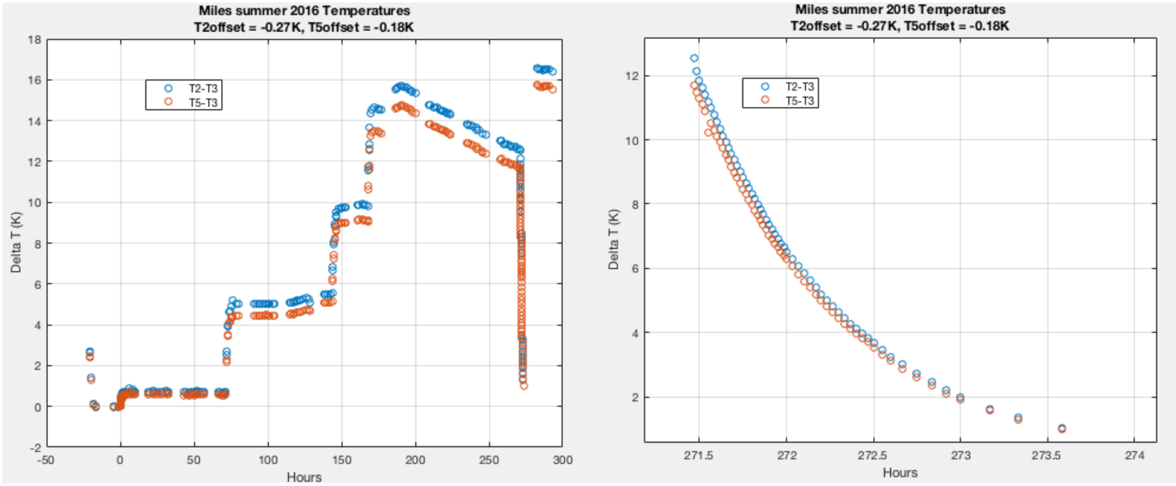
Note: the linear variation from hours 180-270 is due to lowering electrolyte due to level (due to electrolysis in open cell) and can be accurately handled as discussed by Fleischmann, Miles and others.



Looking at the other cell temp (T5)

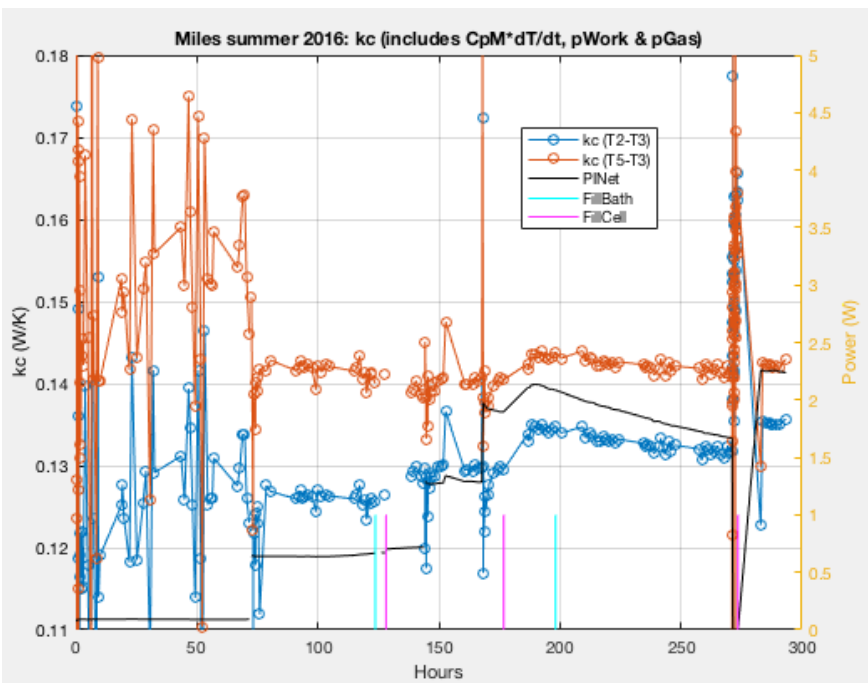
Given the ambiguity in k both as observed variations and potential issues due to location, can other data help validate the excess heat claim? Two sensors were in place to monitor the rise in cell temp, T2 and T5. Miles suggested that T5 was not reliable and should therefore not be used. We wanted to first see if any problems can be seen with T5 by using it to calculate △T.

Delta T's (Tcell - Tbath) track very well for both T2 and T5 as seen in the chart on the left, and the chart on the right showing a close up of the cooling. The offset at higher input power levels is consistent with a difference in radial location of the probe in the oil. T2 appears to be slightly closer to the cell than T5. There is nothing from this data to suggest any problems with T2, T3 or T5. Does T5 confirm the excess heat conclusion?

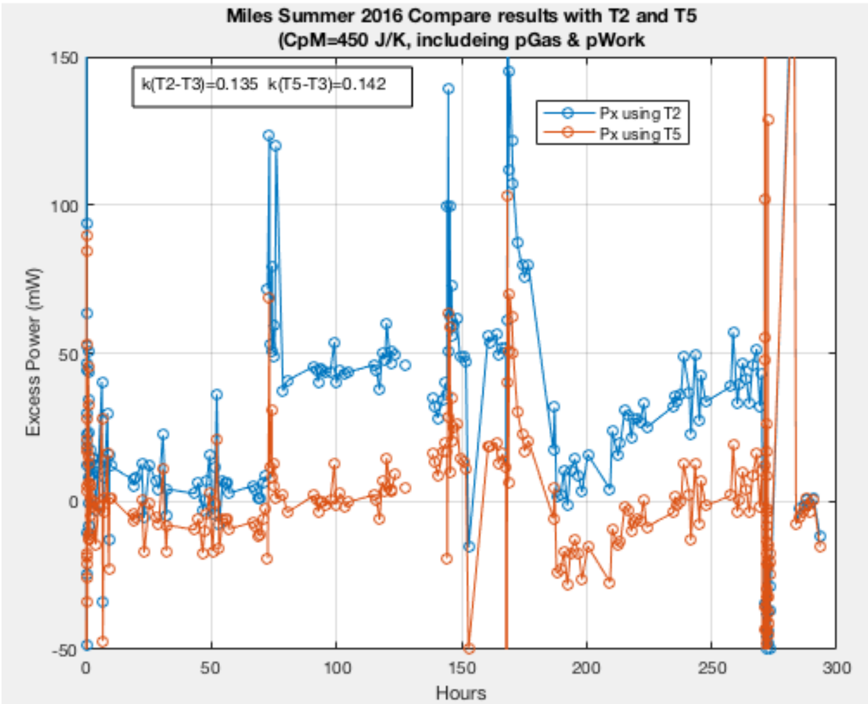


What is k for T5 probe?

The chart below shows k calculated using △T = T5-T3 and compares it to k calculated using △T = T2-T3. If we assume there is no Px at the end of the run (hour 285) then k for T2-T3 is about 0.135, and k for T5-T3 is about 0.142.

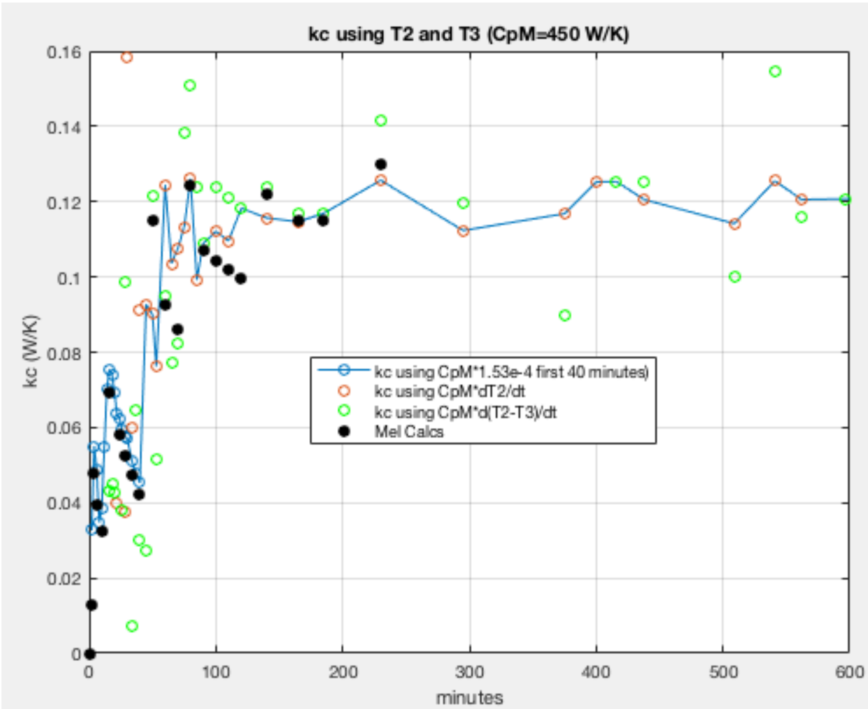


Compare Px using T2 with k=0.135 and T5 with k=0.142. The excess heat computed using T2 is not confirmed by the calculations using the T5 temperature data.

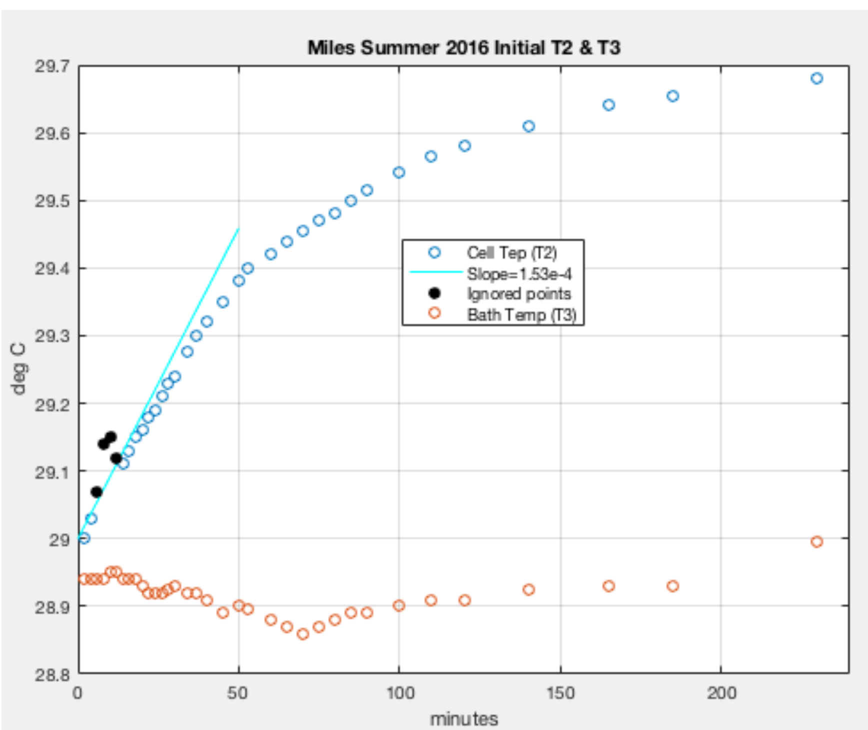


Analysis of initial period

In his presentation Miles shows calculations for k during the first 240 minutes of the run. We were able to match the presented results of the first 40 minutes after learning what smoothing and approximations were used: a linear approximation of d△T/dt for first 40 minutes, and Tbath assumed constant. The chart below shows Mel's calculated k values as well as our calculations using un-smoothed raw data, using constant Tbath assumptions.

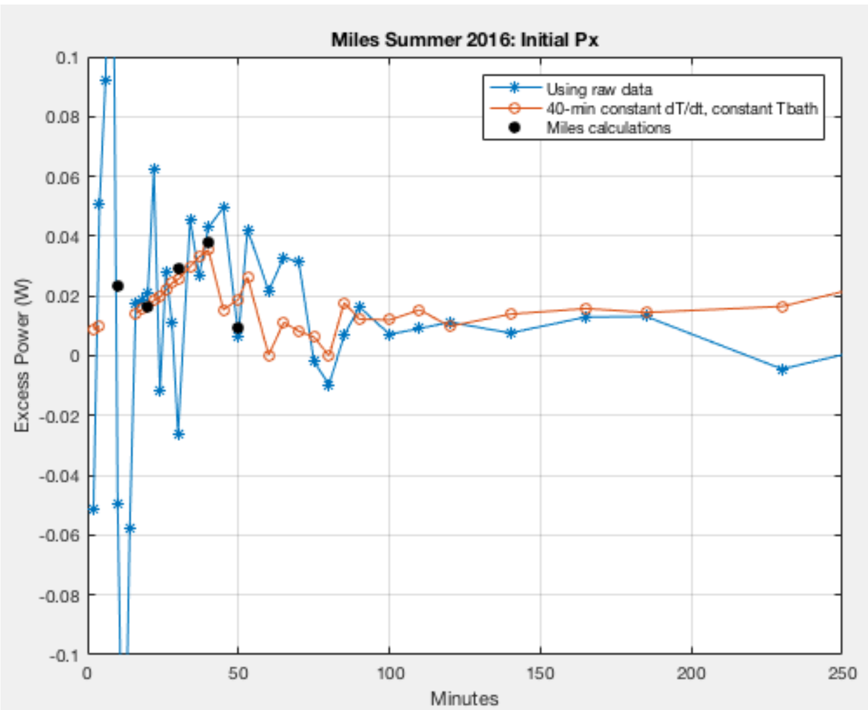


The approximations used above are easier to see when plotted against the raw data as seen in this chart.



Px during initial loading

In private emails Dr. Miles shared calculations of Px during the initial period. In an open cell there is a net 18 kJ/mole heat of loading. If we assume Pd initially loads with 100% current efficiency (i.e. one electron loads one deuteron), it takes about 60 minutes to reach 60% loading for the cathode used in this experiment, and this releases about 7 mW. While there is considerable noise in the Px data, when using k=0.135 Px is greater than can be explained by the energy of loading Pd. The chart below show Px calculated a couple of ways along with the points supplied by Miles.



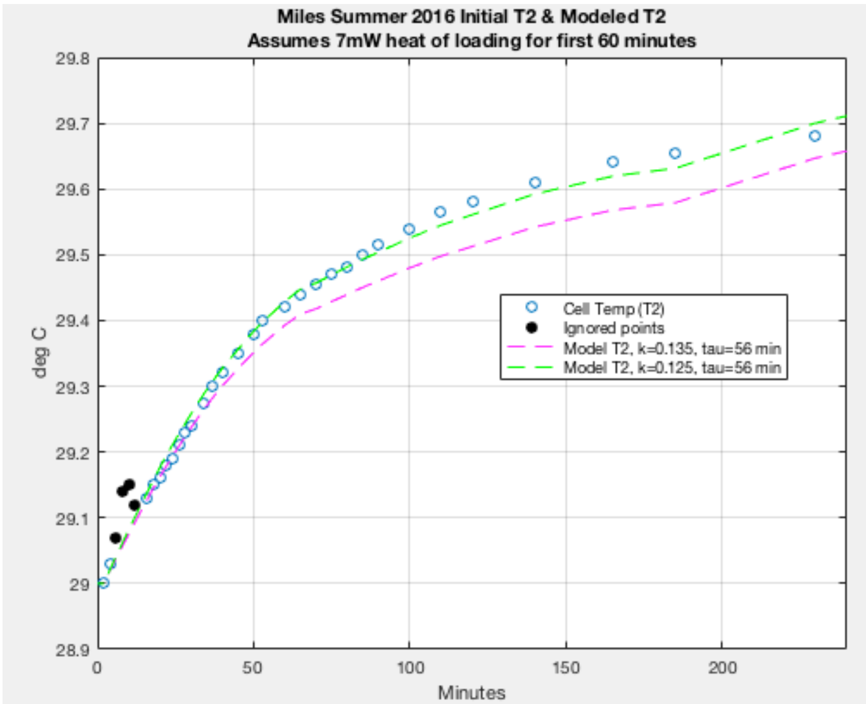
Looking at k and time constant

The basis for the non-steady state Px calculation in this calorimeter is the difference in the measured △T and the expected △T from an ideal 'lumped element' model for CpM. The lumped element model is defined by two constants - k and a time constant 'tau'. Three assumptions are required for this model to give useful calorimetric data:

1. The system can be well modeled with a single lumped-element approximation.
2. k is known and constant (or variations during the run are known and accounted for)
3. time constant 'tau' is known

From the cooling at the end of the run tau is found to be 51 minutes but there was a reduced level of electrolyte at this point in the experiment. From the recommended k=0.135 W/K and CpM=450 J/K we calculate tau = 56 minutes. (tau in seconds = CpM/k)

If we model the cell temp using the assumed values of tau we find a better fit with observed data when using k=0.125. Using this value would mean no Px was produced by the experiment.



Discussion

If the assumption of a constant k with a value of 0.135 W/K is used there is evidence of excess heat being generated from the earliest portion of the run continuing through most of the run.

It is our opinion that the assumption of constant k=0.135 W/K is not justified by the mechanical characteristics of the calorimeter, by the T5 data, or by the initial T2 data.

Based on measured variation in k (stdev 4%), variation between k at beginning of run and end of run (7%), and computed variation with a 1mm movement (3-11%) we argue the uncertainty of the Cu tube calorimeter design, as used in the recent Ridgecrest run with limited control for radial position of glass cell and temperature probes and the irregular and infrequent data sampling, will be several percent. We further argue a more likely interpretation for the data set is no excess heat and a larger than claimed calorimetric uncertainty.

The following table summarized the two interpretations of this data set.

Excess heat interpretation	**Prosaic interpretation**
Excess heat for much of run	No excess - large calorimetric error bars
k is known and constant (k=0.135 W/K), run-to-run and intra-run radial location is unimportant, has negligible effect, or is otherwise controlled	k can vary by single digit percentages run-to-run and intra-run depending on location of cell and probes
T5 is bad - the data is wrong in some manner.	T5 is good, but located in a different radial position giving a different k
Onset of Px was almost immediate - before there was significant D loaded into the Pd	There was no anomalous early heat behavior

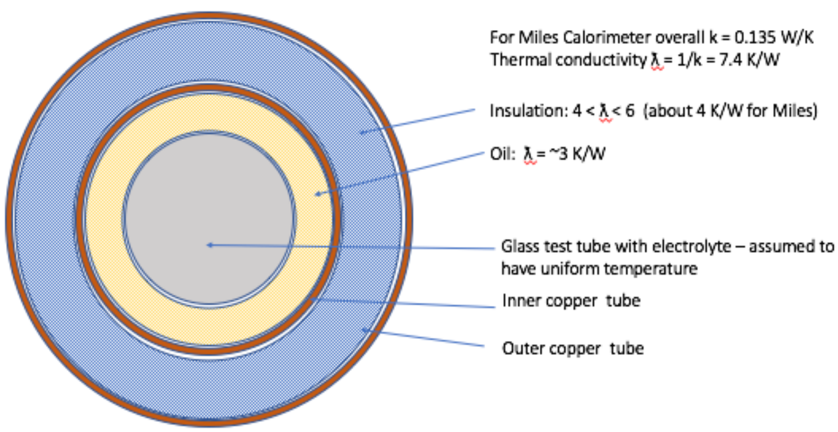
Acknowledgements

The authors gratefully acknowledge Dr. Mel Miles for making his data available for independent analysis. We also acknowledge Miles for patient conversations teaching us his calorimetric techniques.

Appendix

Radial position sensitivity analysis for Miles Cu tube calorimeter

The Miles calorimeter is constructed using two capped concentric copper tubes with insulating material filling the space between the tubes. The inner tube contains a small amount of heat transfer fluid (Mobil 1 synthetic motor oil). The glass cell under test is instrumented with temperature probes on the outside of the glass, held in place with rubber bands. The glass cell and probe assembly is placed in the oil inside the inner copper tube. The diagram below shows the top view of this assembly. Additional details were provided by Miles in his ICCF-15 presentation: http://lenr-canr.org/acrobat/MilesMnewapproac.pdf



The heat transfer of the oil may be calculated from the geometry of the cell, the depth of the oil and the heat transfer coefficient of the oil. The heat transfer coefficient value for mineral oil is about 0.145 W/(mK). The value for synthetic motor oil is ~ 10% higher. A value of 0.16 W/(mK) is used in the calculations shown below.

Miles Calorimenter Heat Flow Calculations

What is the temperature gradient across the oil between the cell wall and the inner copper calorimeter wall?

$r_{Cal\_inner} := \frac{33}{2} mm \quad r_{cell} := \frac{25}{2} mm \quad length := 8cm$

Oil level measured from bottom of inner copper tube

$Area_{cell} := 2 \cdot r_{cell} \cdot \pi \cdot length = 62.832 \cdot cm^2$

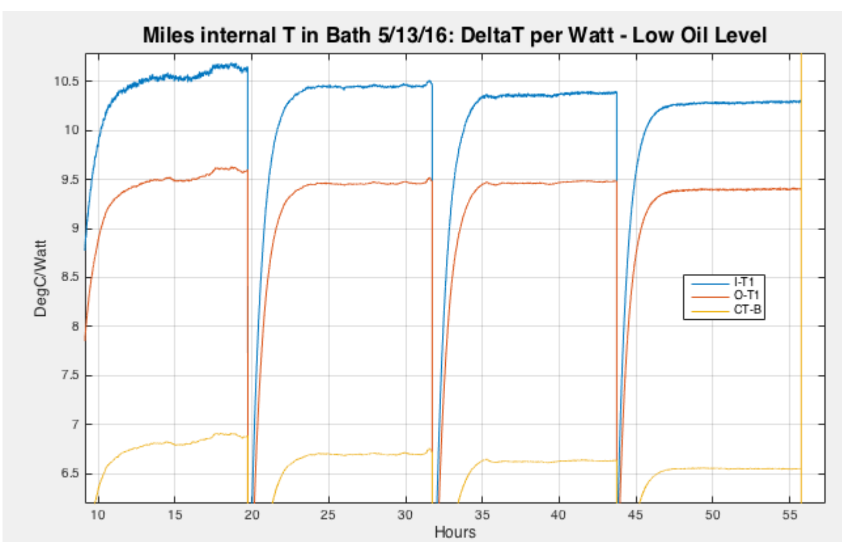
$k_{oil} := .16 \frac{W}{m \cdot K}$

Mineral Oil .145 W/(mK), synthetic ~10% more

$$\Delta T_{oilConcentric} := \frac{\ln\left(\frac{r_{Cal\_inner}}{r_{cell}}\right)}{2 \cdot \pi \cdot length \cdot k_{oil}} = 3.452 \frac{K}{W}$$

Concentric pipe model

From an experimental run at Coolesence with a similar Cu tube design (but different insulation between inner and outer copper tubes) the overall system thermal conductivity (lambda) was approximately 9.5 W/K, and lambda for the oil was measured at ~ 2.8 K/W (difference between rust and yellow curves below) which agrees reasonably well with the calculated 3.4 K/W. In the following analysis 3 K/W is used for the oil portion of the calorimeter.



The effects of a change in the radial position of a temperature probe (test tube assumed centered)

As noted above, the temperature probes are held near the test tube using rubber bands. Here we calculate the sensitivity of a change in radial position of a temperature probe.

There is a significant thermal gradient across the oil. The probe temperature will therefore depend on its radial location. With the probe on the glass, temperature will be at a maximum and will decrease as the probe moves toward the copper tube. The system heat transfer coefficient, lambda, is given by:

$$\lambda_{System} = \lambda_{Insulation} + \lambda_{Oil}$$

$$\lambda_{Oil} = \lambda_{OilMax}\ x/(Diameter_{Outer}\text{-}Diameter_{Inner})$$

For the Miles calorimeter (using Mel's value of k = 0 0.135 K/W) we calculate the following variation in lambda (and hence calorimeter coefficient k) with radial offset x.

lambda Insulation	4.407	W/K		
lambda oil	3	W/K		
Width Oil	4	mm		

Moving Probe Model			
x (mm)	**Lambda System (W/K)**	**k (K/W)**	**% Change**
0	7.407	0.135	0%
0.5	7.032	0.142	5%
1	6.657	0.150	11%
1.5	6.282	0.159	18%

The effects of a change in the radial position of the test tube itself

The radial location of the test tube with respect to the wall of the inner copper tube in the Miles calorimeter is not controlled by mechanical centering rings or other methods. Shifts in the location will change the way heat is carried out of the tube, hence affecting the heat transfer coefficient.

Lambda is maximum when the tube is centered in the oil containing inner copper tube. As the tube moves off center it will transfer more heat out of the side closer to the wall. Using a simple 1-D model heat transfer in the oil is given by:

$W = Diameter_{Outer}\text{-}Diameter_{Inner}$

$$\lambda_{Oil} = \frac{\lambda_{OilMax}}{\frac{W}{W+x} + \frac{W}{W-x}}$$

For the Miles calorimeter (again using Mel's value of k = 0 0.135 K/W) we calculate the following variation in lambda (and hence calorimeter coefficient k) with radial offset x.

lambda Insulation	4.407	W/K			
lambda oil	3	W/K			
Width Oil	4	mm			

Movng cell model				
x (mm)	Oil Fraction	**Lambda System (W/K)**	**k (K/W)**	**% Change**
0.00	1.00	7.407	0.135	0%
0.50	0.98	7.360	0.136	1%
1.00	0.94	7.220	0.139	3%
1.50	0.86	6.985	0.143	6%
2.00	0.75	6.657	0.150	11%

Summary

Because of the relatively poor thermal conductivity of oil there is a significant (relative to the total gradient) thermal gradient in the oil. Therefore, the calorimeter coefficient k for the Cu tube calorimeter is sensitive to the position of the cell within the inner copper tube and to the location of the temperature probes in the oil bath.