A123 Cell Heat Generation under transient cycle

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Lumped Heat Generation

$$I^2 R_e$$

- $QI^2Re\_max=14.8877W$
- $QI^2Re\_mean=1.6121W$

Resistive Dissipation Heat Generation

$$\dot{Q}=\boxed{I(V-U^{\mathrm{avg}})}+IT\frac{\partial U^{\mathrm{avg}}}{\partial T}-\sum_i \Delta H_i^{\mathrm{avg}} r_i-\int\sum_j\left(\bar{H}_j-\bar{H}_j^{\mathrm{avg}}\right)\frac{\partial c_j}{\partial t}dv, \tag{3}$$

- QI(U-V)_max=9.6659W
- QI(U-V)_mean=1.2312W

Entropic Heat Generation

$$\dot{Q}=I(V-U^{\mathrm{avg}})+\boxed{IT\frac{\partial U^{\mathrm{avg}}}{\partial T}}-\sum_i \Delta H_i^{\mathrm{avg}} r_i-\int\sum_j\left(\bar{H}_j-\bar{H}_j^{\mathrm{avg}}\right)\frac{\partial c_j}{\partial t}dv, \tag{3}$$

- -0.3mV/K<dU/dT<0.2mV/K
- I=32.3A Max UAC Current
- Ts=31^{o}C=304.15K Max Temp
- -2.9472W<ITdU/dT<1.9648W

- UAC SOC: 50% to 35%
- 5.5e-5V/K to -9.9e-6V/K
- 0.5403W to -0.0973W

- Qent_max=0.4823W
- Qent_mean=-0.0023W

Forgez et.Al. 2010

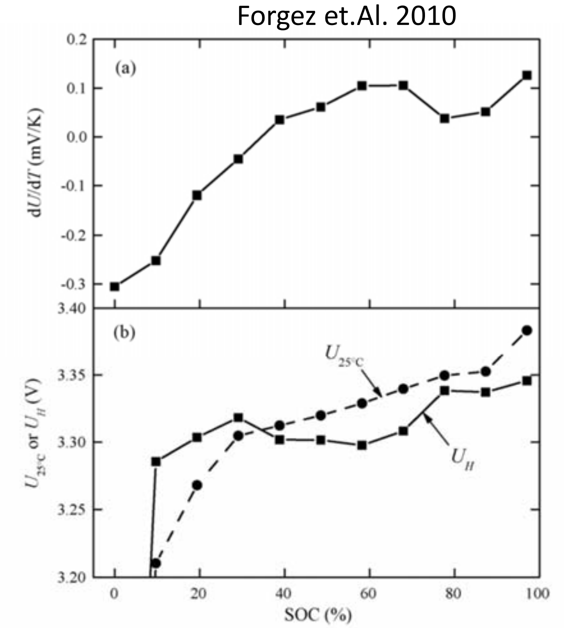


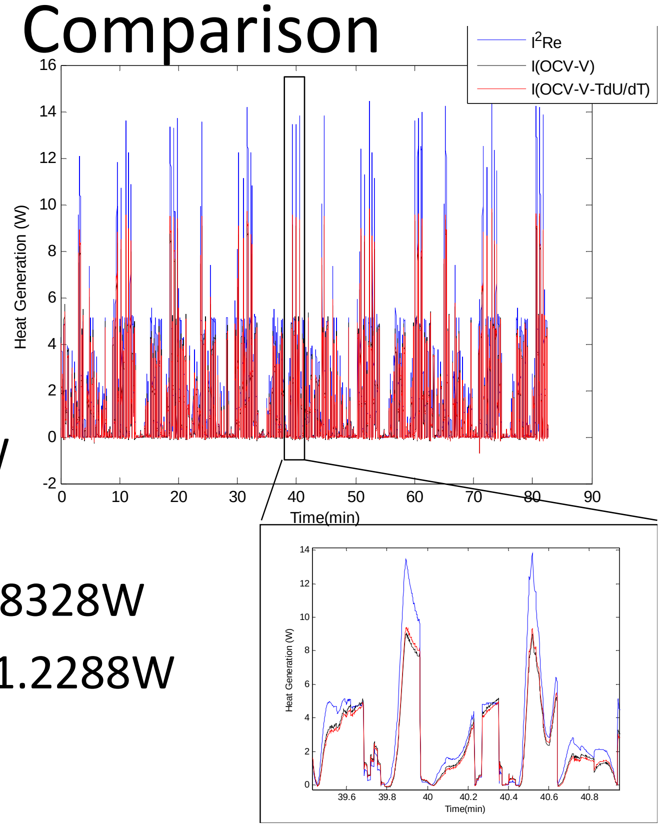
Fig. 4. (a) Temperature coefficient $\partial U/\partial T$ and (b) equilibrium potential at 25 °C $U_{25\,°C}$ and enthalpy potential U_H as a function of SOC.

Heat Gen Comparison

- $QI^2Re\_peak=14.8877W$
- $QI^2Re\_mean=1.6121W$

- QI(U-V)_max=9.6659W
- QI(U-V)_mean=1.2312W

- QI(U-V-TdU/dT)_max=9.8328W
- QI(U-V-TdU/dT)_mean=1.2288W

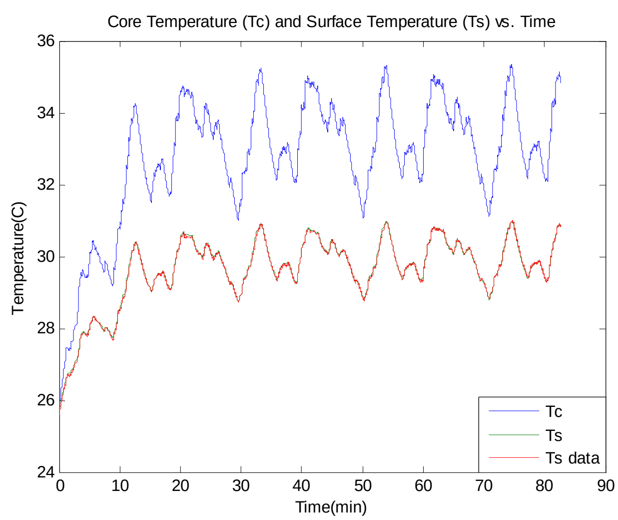


$Q=I^2Re$

ID Results

- Cc=71
- Cs=6
- Rc=2.11
- Ru=2.39
- Re=0.01427

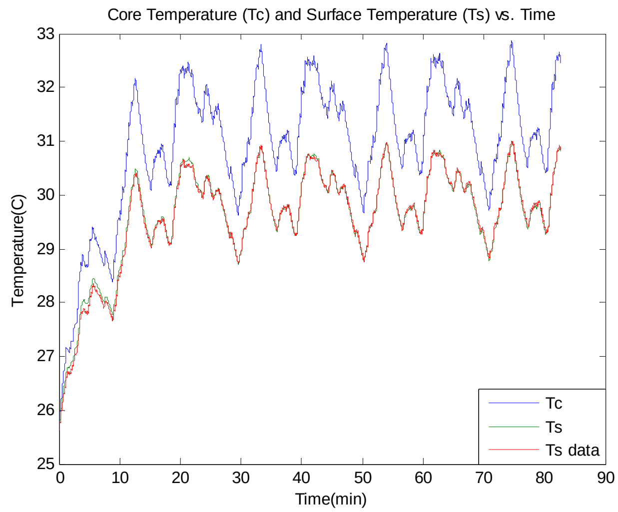
- Tc-Ts=4.34°C



Q=I(OCV-V)

ID Results

- Cs=8.3
- Cc=71.27
- Rc=1.16
- Ru=3.13

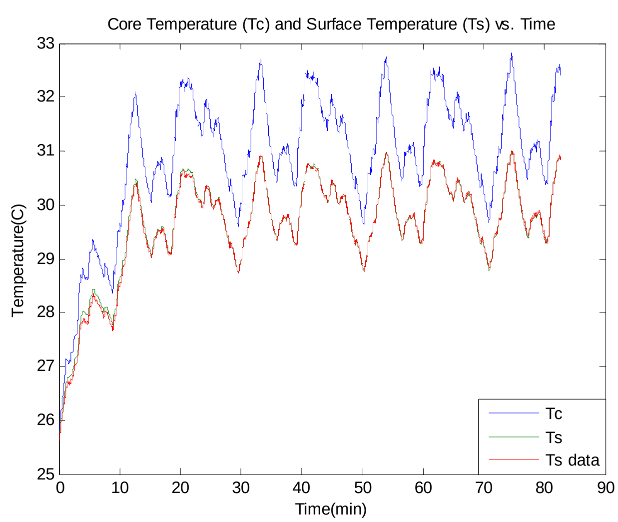


- Tc-Ts=1.8°C

Q=I(OCV-V-TdU/dT)

ID Results

- Cs=8.3
- Cc=71.95
- Rc=1.1139
- Ru=3.1421

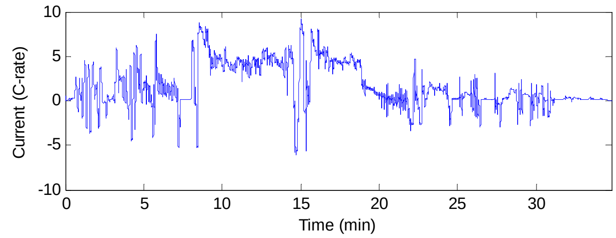


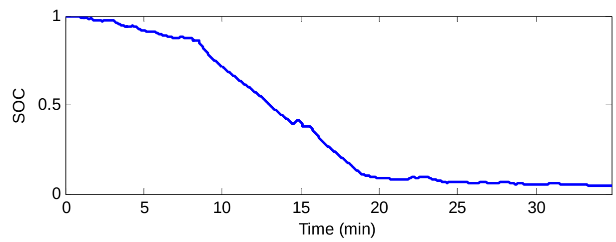
- Tc-Ts=1.79°C

Test with larger SOC swing

Ford PHEV cycle

- Start from 100% SOC
- Down to 5% SOC
- Max current: 10 C
- 2.1Ah LiFePo4





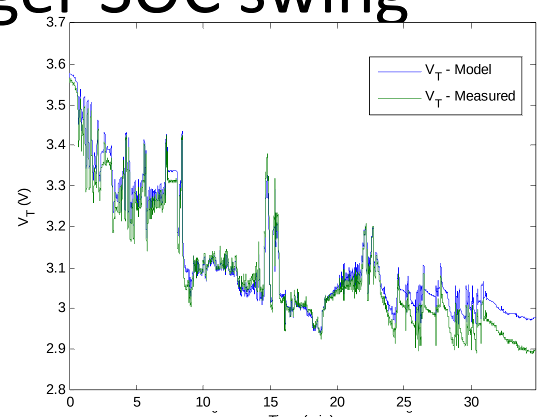
Test with larger SOC swing

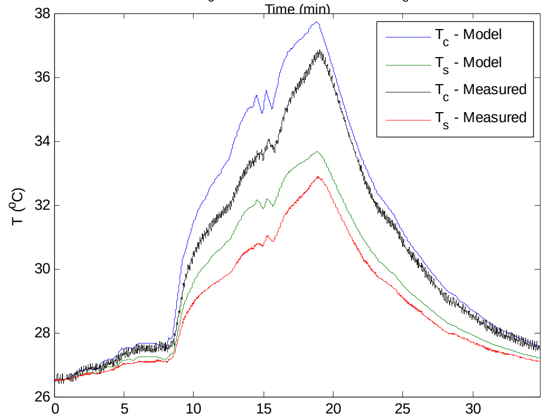
Voltage estimation

- Good before 23 mins
- Worse when SOC<10%

Temperature estimation

- Model higher by 1^{o}C
- Maybe due to the missing entropic heat generation?

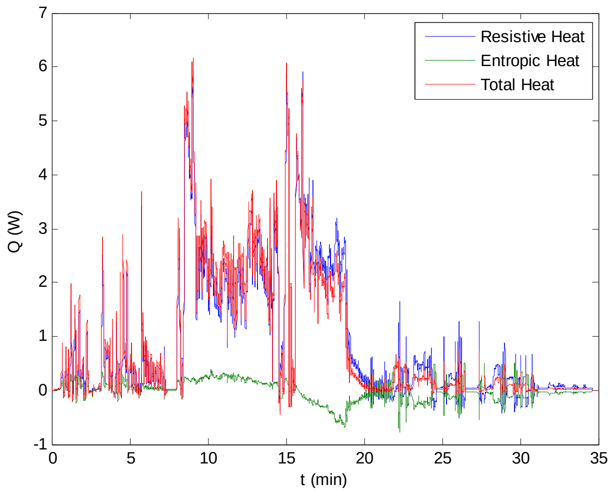




Test with larger SOC swing

Entropic Heat

- Calculated by $IT\frac{\partial U^{avg}}{\partial T}$
  Forgez 2010 JPS
- Positive when SOC>40% (before 15 mins)
- Negative when SOC<40% (after 15 mins)
- Significant when SOC<20%



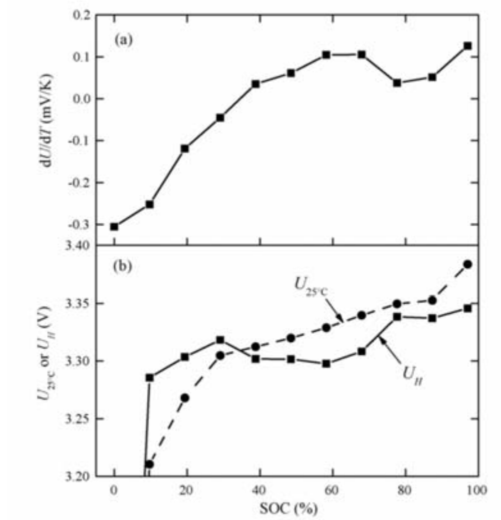


Fig. 4. (a) Temperature coefficient $\partial U/\partial T$ and (b) equilibrium potential at 25 °C $U_{25°C}$ and enthalpy potential U_H as a function of SOC.

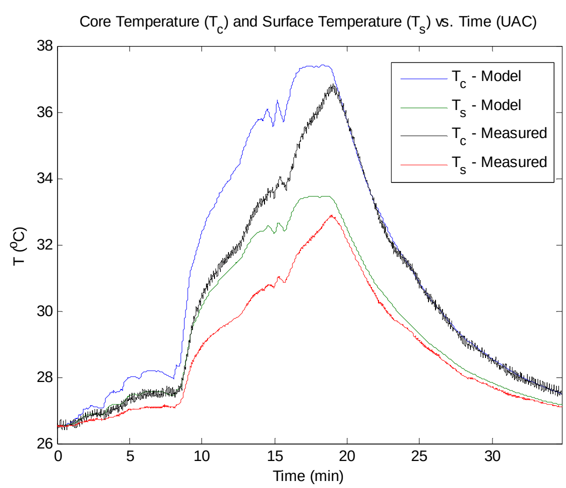
Forgez 2010 JPS

Thermal modeling of a cylindrical LiFePO4/graphite lithium-ion battery

Test with larger SOC swing

Temperature estimation

- Different when entropic heat is included
- Entropic heat is small under the parameterization cycle
  (SOC varying around 50%)
- Entropic heat more significant when battery SOC runs under 20% SOC
- Parameterization of thermal model might need to be performed in low SOC with entropic heat taken into account



Temp estimation considering entropic heat generation