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Development of an Advanced 2D -Thermal Model for Large size Lithium-ion Pouch Cells

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Outline

1. Introduction

2. Methodology

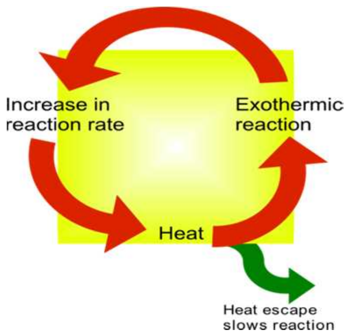
3. Results and discussion

4. Summary

INTRODUCTION

- In EVs, large format of Li-ions cell are subjected to abuse stress regimes

- Significant temperature Increase



Dissipated heat not sufficient

thermal runaway

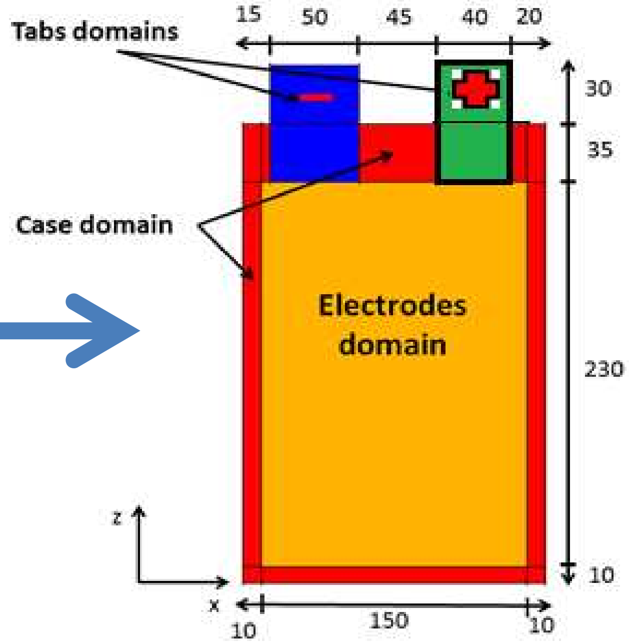
- Decrease of lifetime and performance

- Less Heterogeneous heat distribution In large cell,

- Need for thermal model: cooling system and optimized cell design

2. Methodology: Geometry

Large size
small thickness



2D (mm)

- Thickness: 13 mm
- Chemistry: $LiFePO_4$/graphite
- Capacity: 45 Ah
- Tab material: Al, Cu
- Case domain: Al
- Electrode domain: equivalent material

2. Methodology: Equations

- Electrode and tabs domains:

$$k\left[\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial z^2}\right]+q_g=\rho . C_p\frac{\partial T}{\partial t}$$

Electrode

$$q_g=\frac{1}{V_{bat}}\left[RI^2+\left(T\left[\frac{dE}{dT}\right]\right)I\right]$$

Internal resistance
Irreversible heat

Entropy coefficient
Reversible heat

Tabs

$$q_g=\frac{R'I^2}{V_{tab}};\quad R'=\rho'\frac{l}{S}$$

Tab resistance

- Case domains:

$$k\left[\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial z^2}\right]=\rho . C_p\frac{\partial T}{\partial t}$$

2. Methodology: Equations

- heat flux from battery surface to the surrounding:

$$q_s = -k\left(\frac{\partial T}{\partial x} + \frac{\partial T}{\partial y}\right)|_{boundaries} = (h_{conv} + h_{rad})(T - T_a)$$

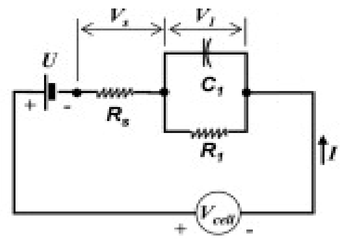
$$h_{rad} = \epsilon\sigma(T^2 + T_a^2)(T + T_a)$$ Radiative heat transfer coefficient

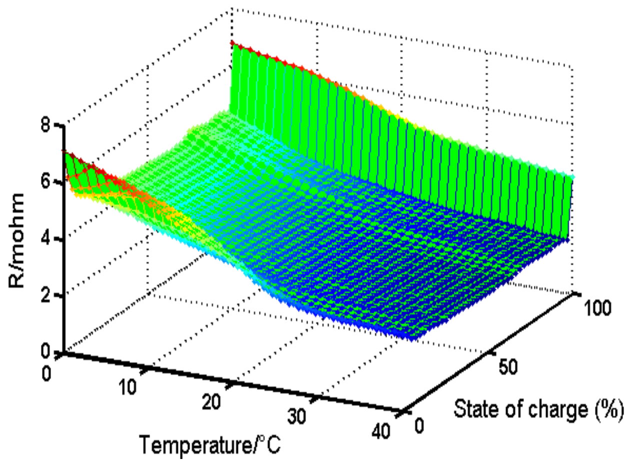
h_{conv} convective heat transfer coefficient

2. Methodology: heat source

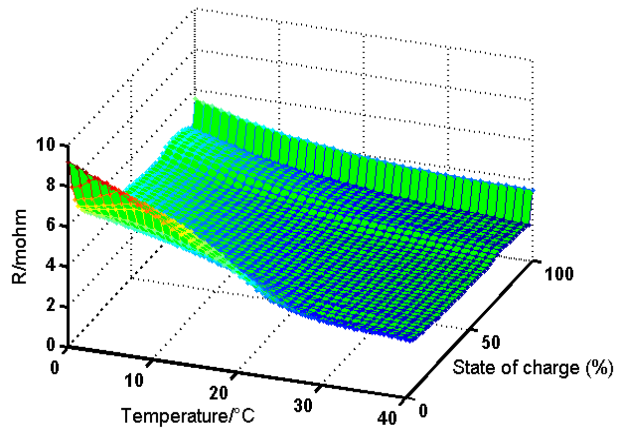
- Resistance: HPPC characterization test

Cauer 1st order





Charge at 1It



discharge at 1It

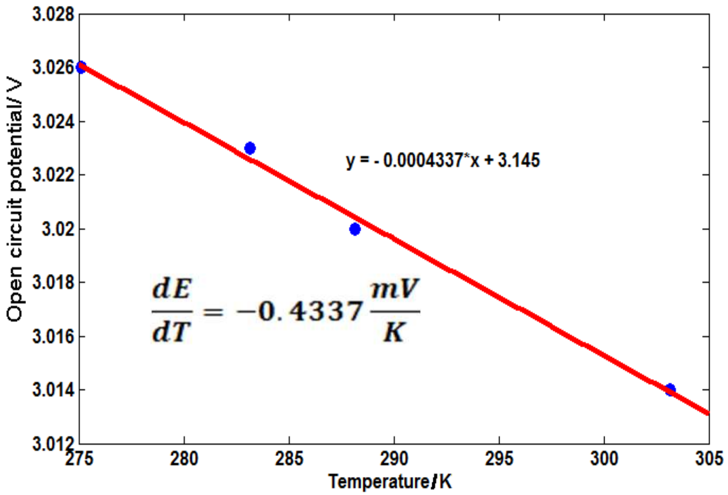
R=R(SoC, T, I)

The experiment is repeated at different current rate

2. Methodology: heat source

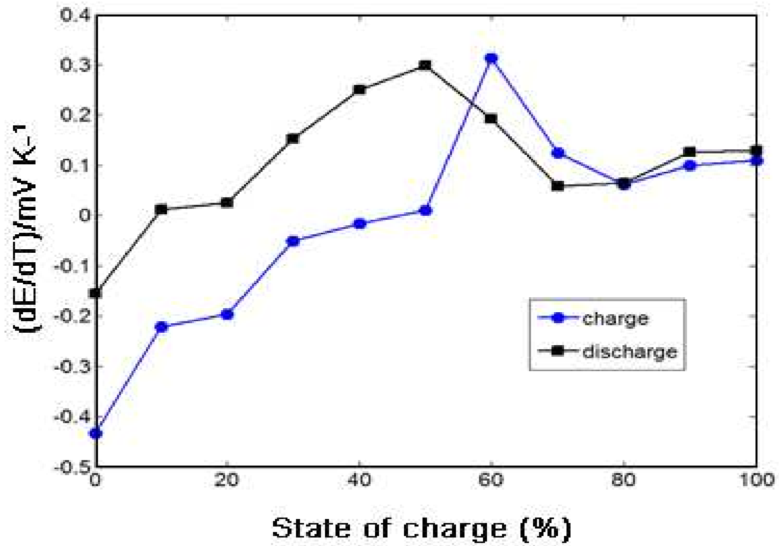
❑ Entropy coefficient measurement $\frac{dE}{dT}$

Entropy coefficient at 0% of SoC



At 0% of SoC , Open circuit potential at different temperature

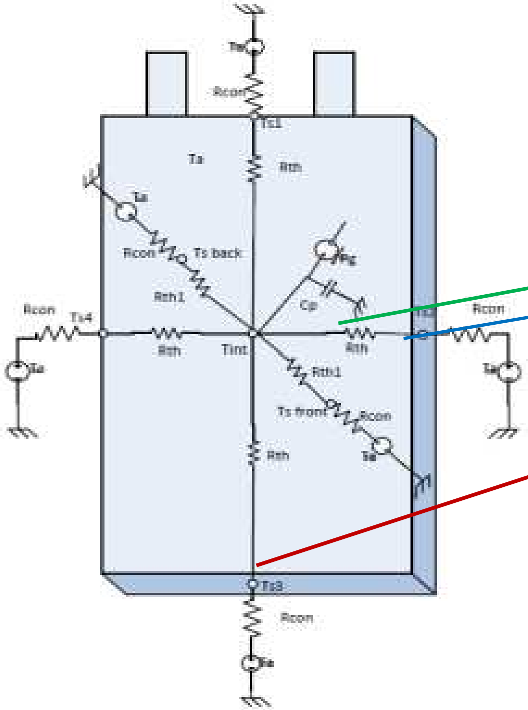
Entropy coefficient at Charge and disharge process



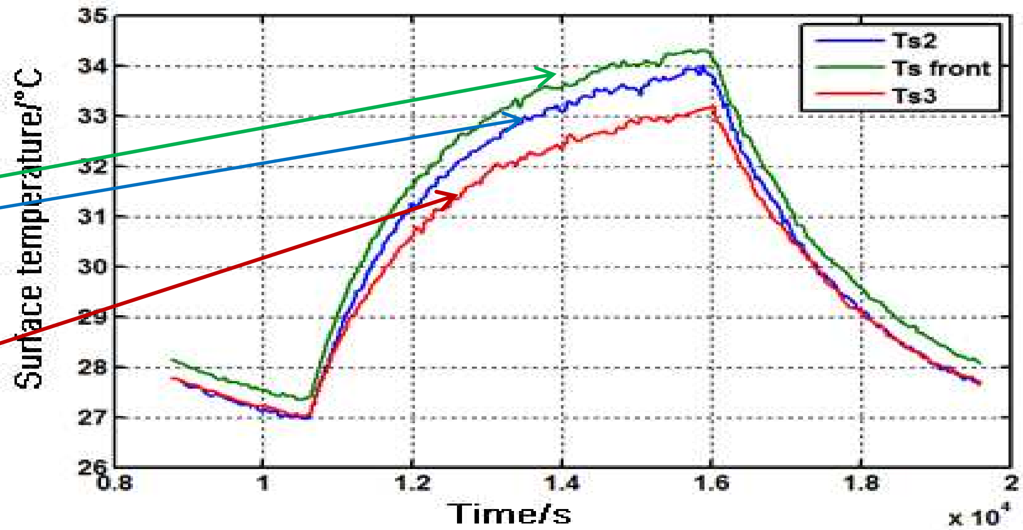
-difference due to hysteresis
-endothermic or exothermic according to the It-rate

2. Methodology:
thermal parameters

❖Thermal conductivity and capacitance estimation of the electrode domain



-pulse test in order to reach the steady state

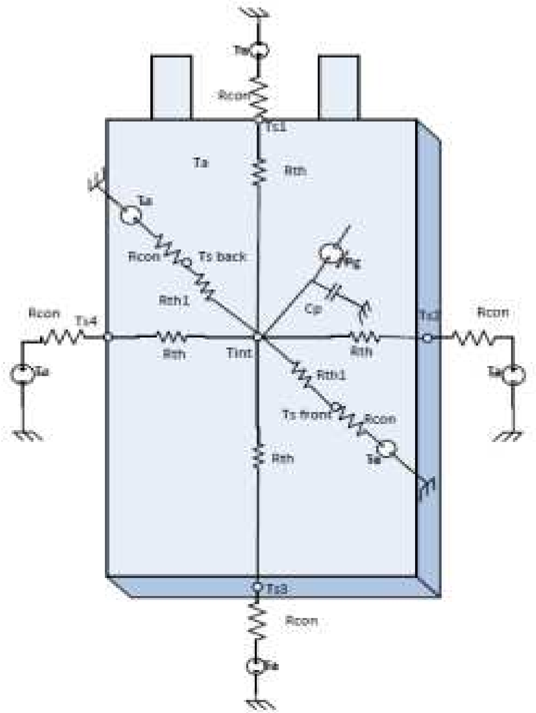


-Ratio of heat in each direction from the energy balance

$$P_1 = 0.45\, P_g \; ; \; P_2 = 0.03\, P_g \; ; \; P_3 = 0.02\, P_g$$

2. Methodology:
thermal parameters

❖Thermal conductivity and capacitance estimation of the electrode domain

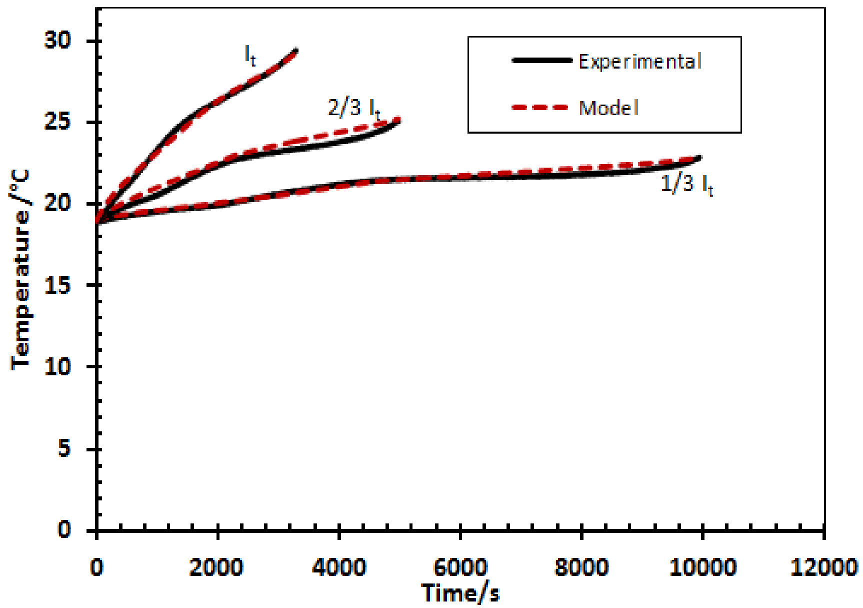


-From curve fitting tool method

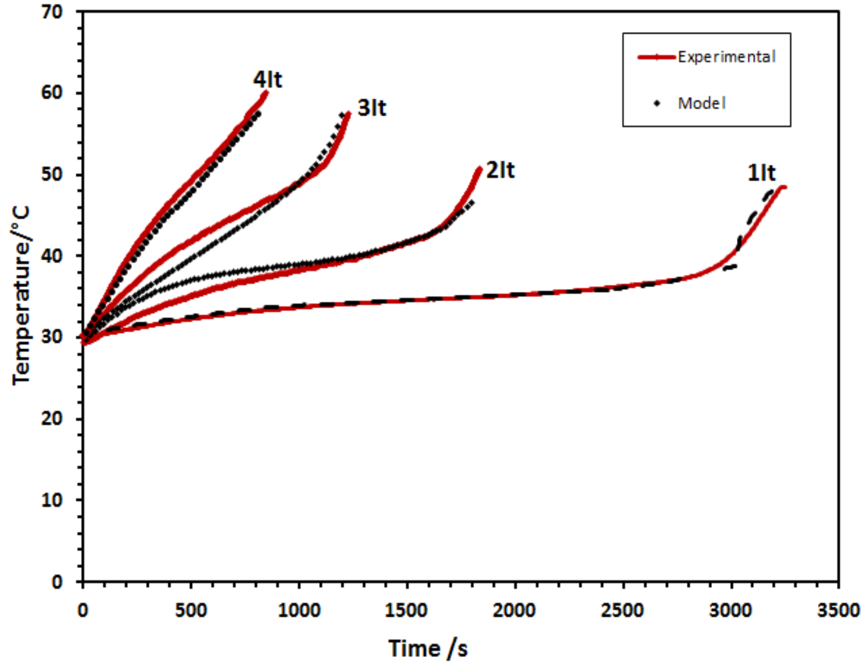
	C_p ($J\ kg^{-1}\ K^{-1}$)	R_{th1} ($°C\ W^{-1}$)	R_{th} ($°C\ W^{-1}$)	R_{con} ($°C\ W^{-1}$)	h ($Wm^{-2}K^{-1}$)	k_1 ($Wm^{-1}K^{-1}$)	k ($Wm^{-1}K^{-1}$)
.5 I_t	645,01	0,62	0,89	0,95	30,41	0,3	28,13
I_t	636,05	0,65	0,81	1,14	25,21	0,28	32,68
I_t	575,03	0,66	0,74	1,21	23,79	0,28	33,50

3. Results

ANSYS software



Charge at different It



Discharge at different It

EVS 27

2. Results

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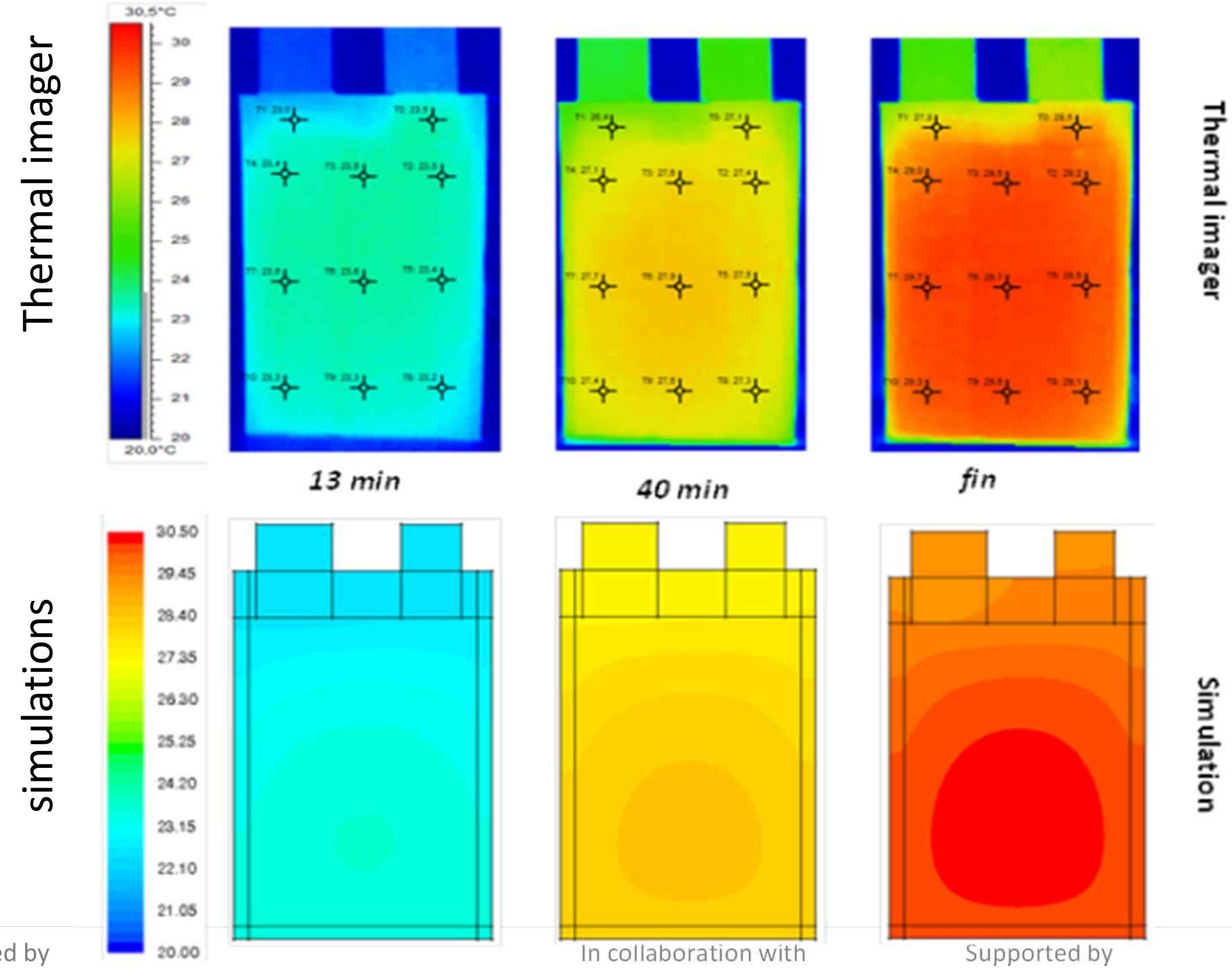
- ❑Charge at 1It

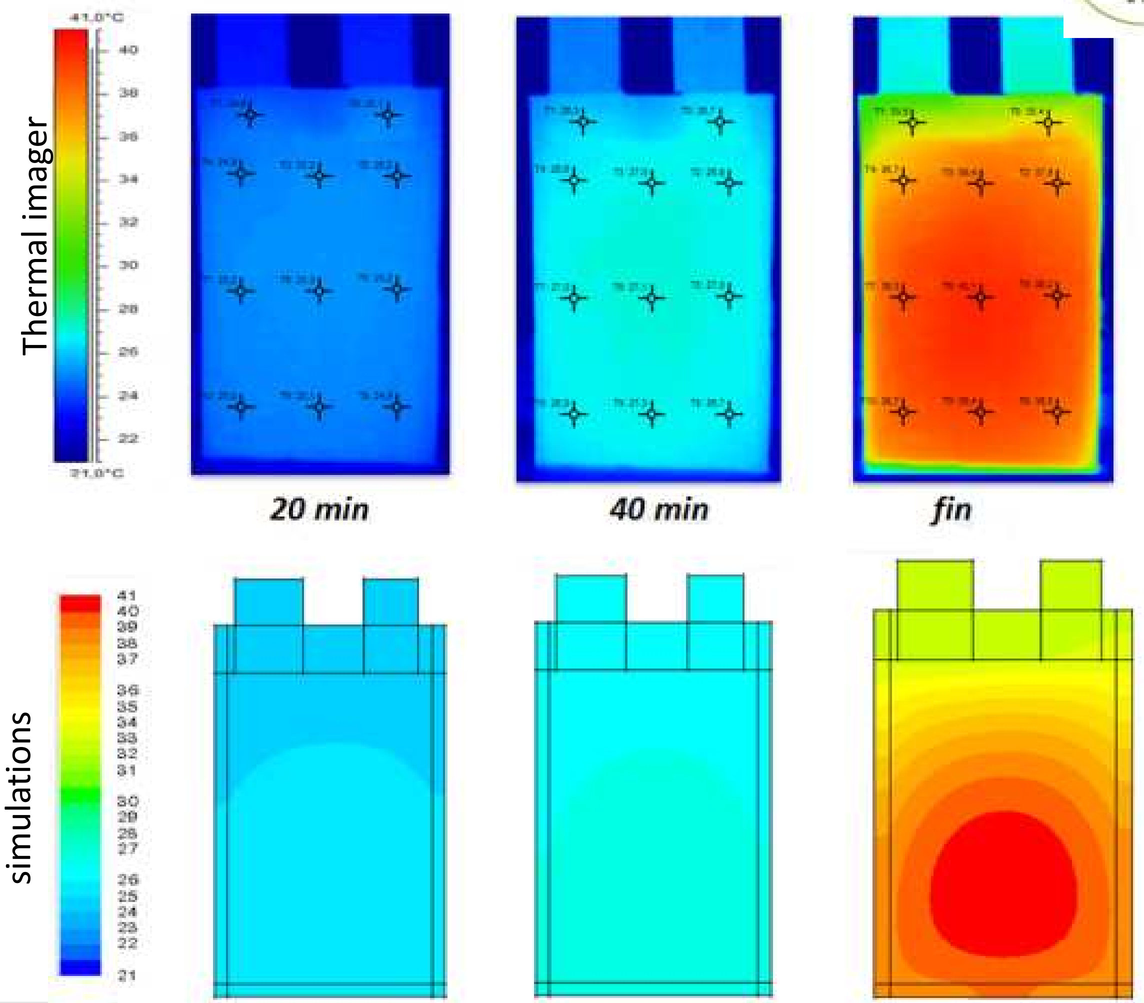
Thermal distributions
ΔT< 1 ° C



2. Results

- Discharge at 1It

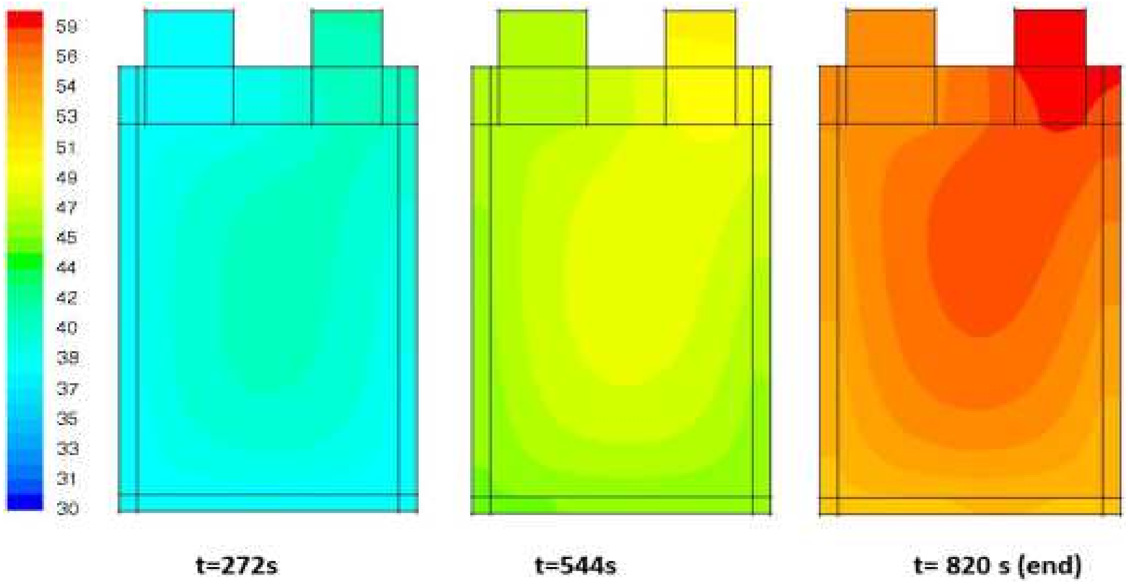
Thermal distributions
ΔT< 4 ° C



2. Results

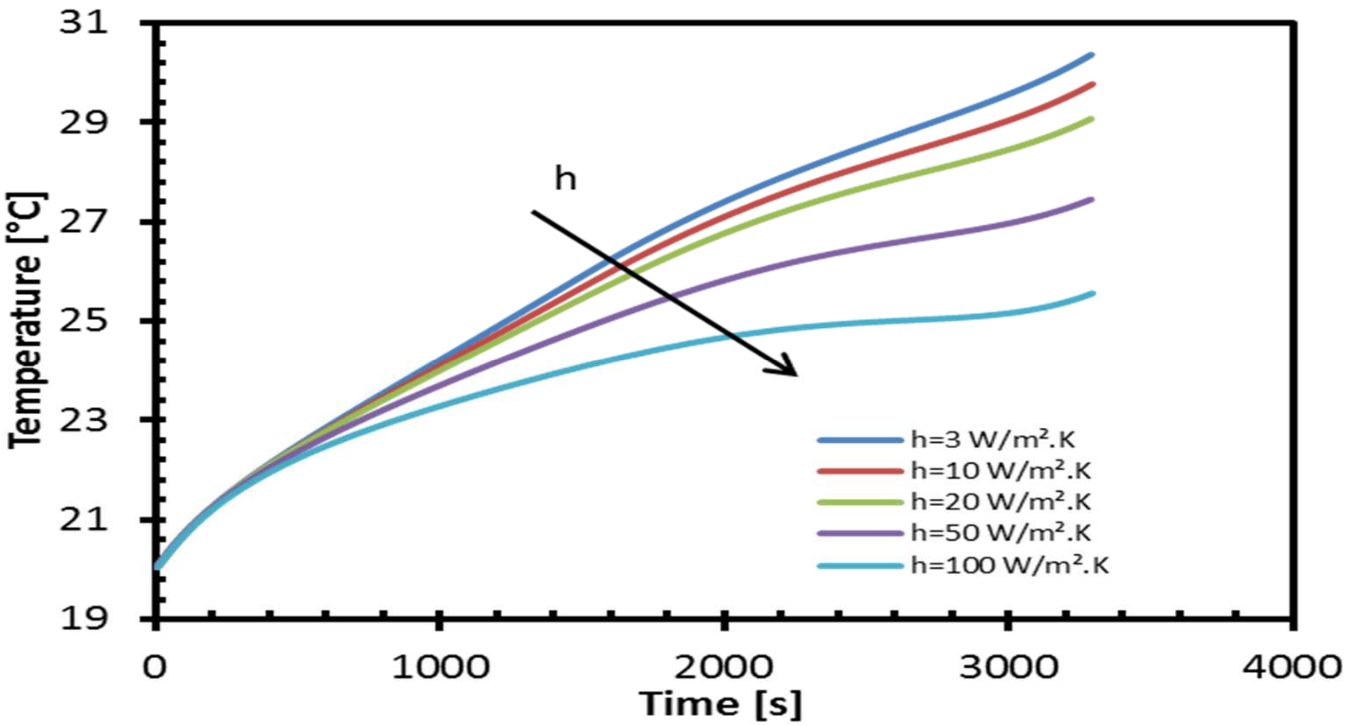
- Discharge at 4It

Thermal distributions
ΔT< 6 ° C



2. Results

❑ Influence of cooling system at 1It charge rate




THANK YOU!