Simulation and Design of Lithium Ion Battery Packs for the Altitude Conditions in Northern Chile

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Introduction: One of the effects in loss of performance and capacity of thermal systems is produced by altitude. This causes the density of a compressible fluid and atmospheric pressure, is considerably reduced, causing a decrease in electrical power and thermal systems. Given this, the packages of lithium ion batteries that use forced cooling by a compressible fluid, are directly affected losing cooling capacity, and decreased performance.

In this poster, is modeled in COMSOL® the impact of temperature and altitude over sea level, in the design of a pack of lithium ion batteries using forced cooling.

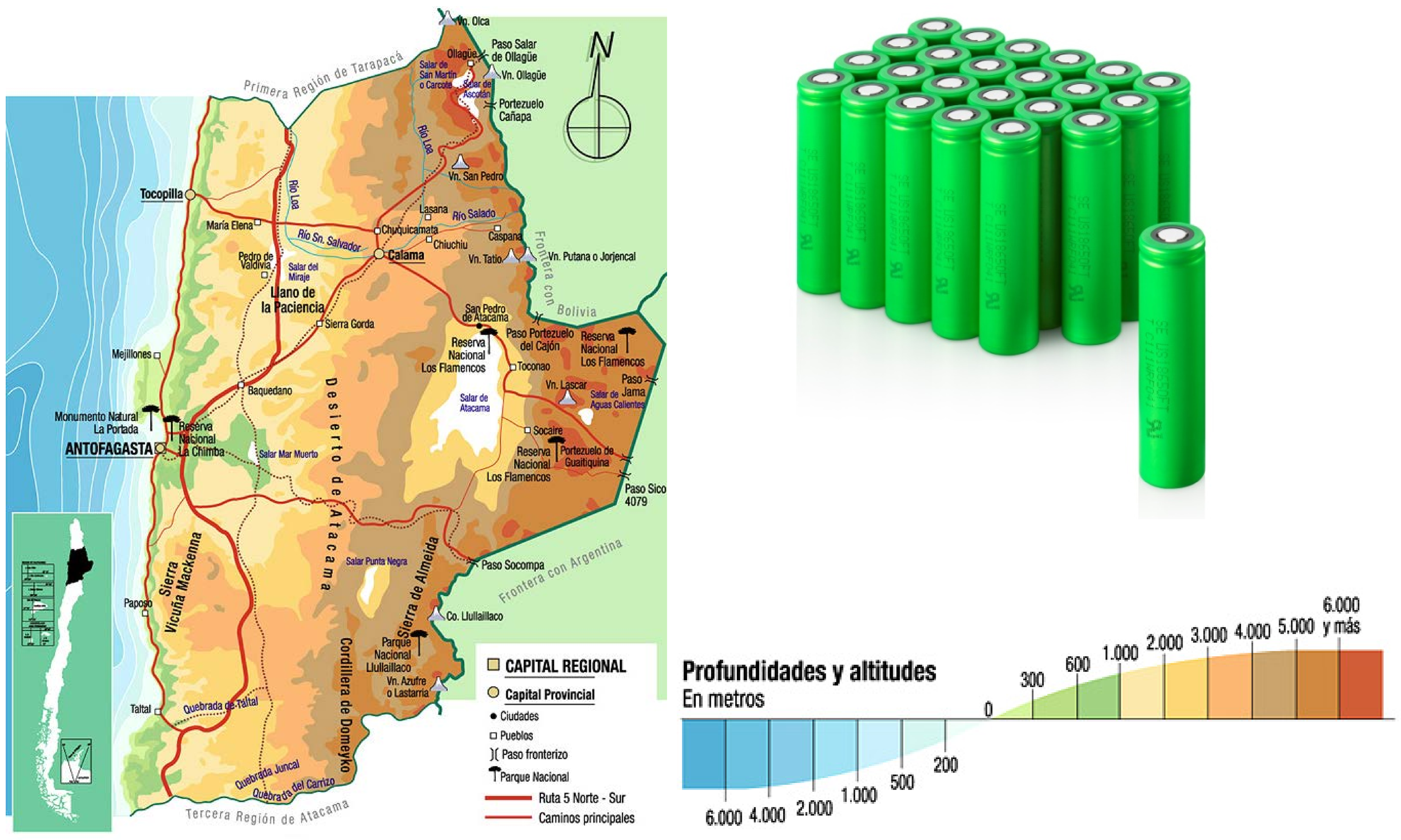

Figure 1. Effect of altitude on lithium battery packs

Computational Methods:

A simple way to express the pressure change with altitude is the general equation of hydrostatic, which generally applies in non-compressible fluids, but is also applicable to compressible fluids.

$$\frac{dP}{dz} = -\rho g \qquad \frac{\partial \rho}{\partial t} = \frac{\partial \rho}{\partial P}\frac{\partial P}{\partial t}$$

The evaluation of the density derivative with respect to pressure can be obtained from the equation of state of a compressible ideal gas.

For our case, we used a packet of 40 ordered cells in 10 columns with 4 parallel rows, of which 4 cells were connected in parallel and 10 cells connected in series. Based on a finite volume analysis, a solution is found for each volume of the enmeshed region. For our case, the mesh has 18,297 nodes and 16,507 elements distributed like in the figure 2.

the simulation was performed at steady state because the variations over time of the physical quantities are periodic and are repeated almost identically. The input temperature to the system is 25 C and the output was defined according to ambient atmospheric pressure.

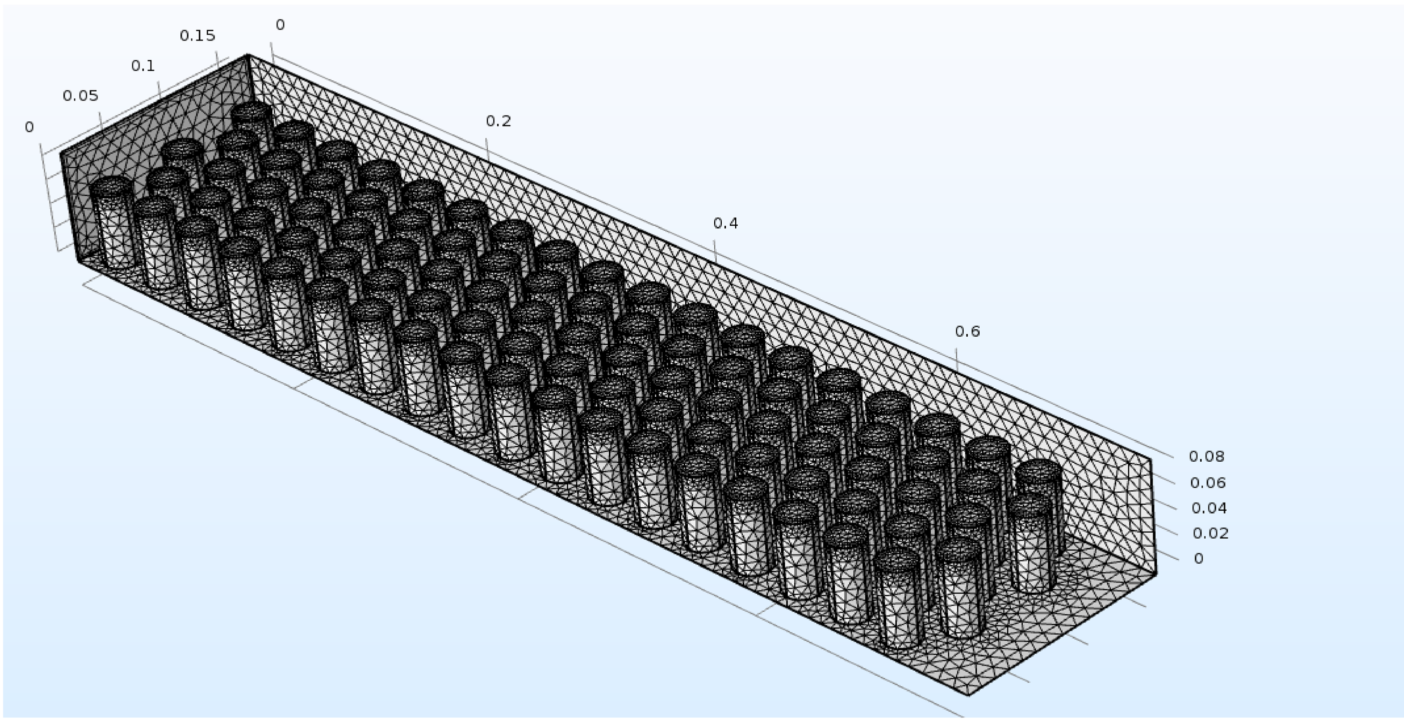

Figure 2. Enclosure of the lithium-ion battery system

Results:

The variable that can be analyzed in the design of a battery pack is the temperature. In order to quantify this variable, different simulations were performed with different configurations. The figure 3 shows to an altitude of 4000 m.s.n.m. for a staggered configuration consisting of 40 cells connected electrically in series and arranged in 10 columns and 4 rows. A cylindrical cell $LiFePO_4$, type ANR 26650 manufactured by A123 System was used. The characteristics of the cell and simulation parameters are: V_{oc} = 3.35 (V), 2.5 Ah, D = 2.6 cm, S_L = 3.3 cm, S_T = 3.4 cm, T_∞ = 24 C, V = 0.1 m / s. As a charging current, a discharge pulse of 3C is applied for 15 minutes, and 0.5C is charged for 15 minutes.

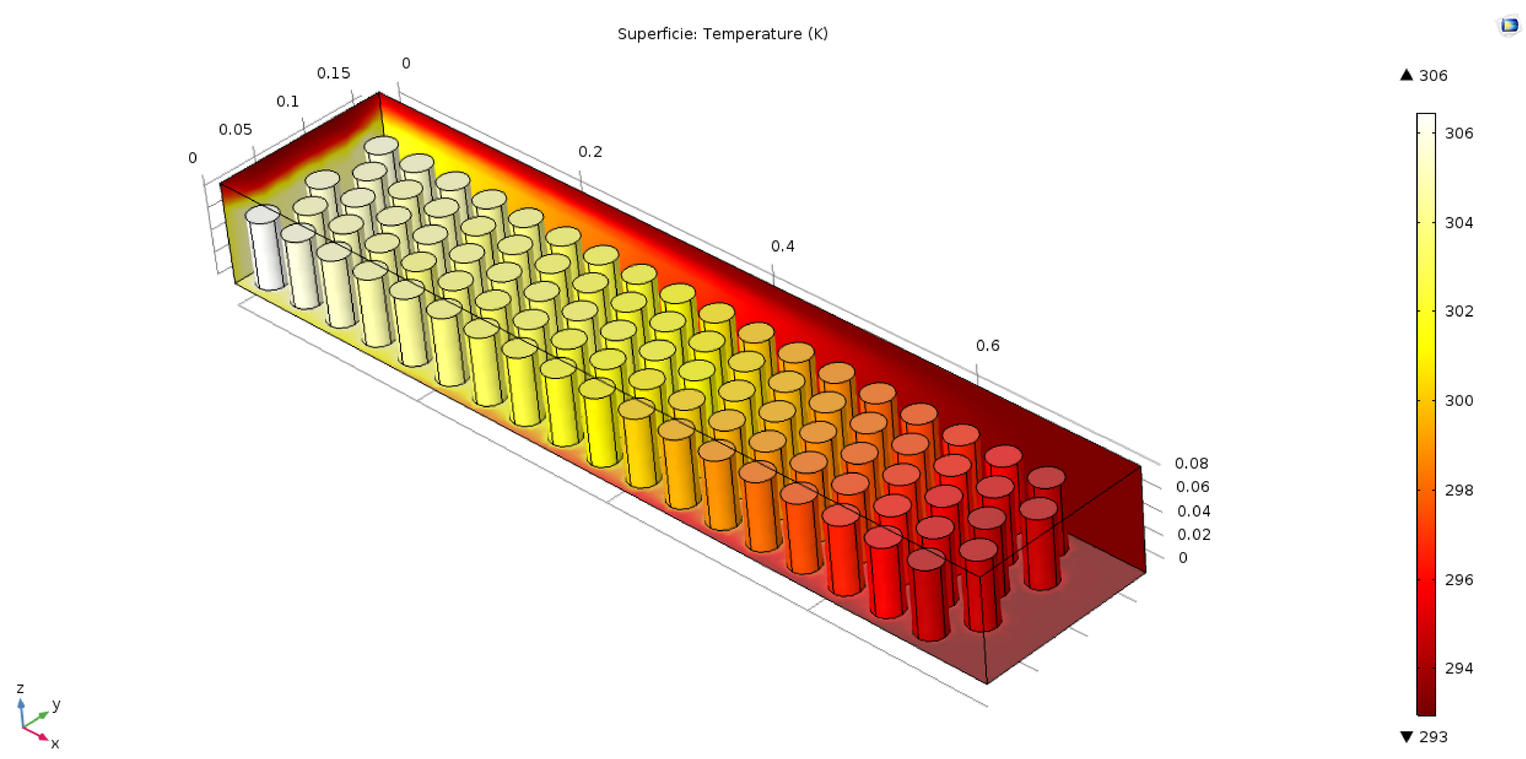

Figure 3. Simulation of Lithium Battery

Conclusions:

The height represents a very important variable to be taken into account for any thermal - electrical design that is generally not assumed as a relevant factor, in the world due to the commercial quantity destined to places with considerable geographical heights.

References:

1. S. Al Hallaj, H. Maleki, J. S. Hong, and J. R. Selman, "Thermal modeling and design considerations of lithium-ion batteries," Journal of Power Sources, vol. 83, pp. 1-8, October 1999.