Task 2: Calculate the Capacity Factor

June 11, 2021

In order to evaluate the performance of the storage, non-dimensional *observables* need to be defined. One of them is the capacity factor CF:

$$CF = \frac{Q_{b.d} - Q_{b.c}}{Q_{max}}$$

with $Q_{b.d}$ and $Q_{b.c}$ being the thermal energy stored before discharging and charging, and Q_{max} the maximal thermal energy that can be potentially stored:

$$Q(t) = \frac{\pi}{4} D^2 \left[\varepsilon \rho_f C_f \int (T_f - T_{cold}) dx + (1 - \varepsilon) \rho_s C_s \int (T_s - T_{cold}) dx \right], \tag{7}$$

$$Q_{max} = \frac{\pi}{4} D^2 L (T_{hot} - T_{cold}) [\varepsilon \rho_f C_f + (1 - \varepsilon) \rho_s C_s]. \tag{8}$$

As we see, the capacity factor depends on many factors, which again depend on

an 8-dimensional variable which we'll call y, in the following way:

$$\begin{aligned} \rho_s &= \rho_s^0 (1 + \sigma G_1(y)), & \rho_f &= \rho_f^0 (1 + \sigma G_2(y)) \\ C_s &= C_s^0 (1 + \sigma G_3(y)), & C_f &= C_f^0 (1 + \sigma G_4(y)) \\ m_f &= m_f^0 (1 + \sigma G_5(y)), & d &= d^0 (1 + \sigma G_6(y)) \\ D &= D^0 (1 + \sigma G_7(y)), & V &= V^0 (1 + \sigma G_8(y)) \end{aligned} \tag{9}$$

Assuming a sequence of low-discrepancy Sobol points $\{y_k\}_{k=1}^n$ each y_k is transformed according to (9), then solving the following system of equations

$$\begin{aligned} \varepsilon \rho_f C_f \frac{\partial T_f}{\partial t} + \varepsilon \rho_f C_f u_f \frac{\partial T_f}{\partial x} &= \lambda_f \frac{\partial^2 T_f}{\partial x^2} - h_v (T_f - T_s) \quad x \in [0, L],\ t \in [0, T], \\ (1 - \varepsilon) \rho_s C_s \frac{\partial T_s}{\partial t} &= \lambda_s \frac{\partial^2 T_s}{\partial x^2} + h_v (T_f - T_s) \quad x \in [0, L],\ t \in [0, T], \end{aligned}$$

on a mesh with x different spatial points. Finally, a training set is constructed by calculating CF.
Three different training sets are constructed for three different x (x = 101,401,1601), with correspondingly different sample sizes.
Objective:
Using the given training sets, train a model to find the approximate map y $\rightarrow$ CF(y).

My Approach:
I used a multi-level approach (see Lie, Mishra, Molinaro: *A Multi-level procedure for enhancing accuracy of machine learning algorithms*, arXiv:1909.09448).