Information:

You are looking at a production with the following steps:

1. Preparation and material input
2. Heating
3. Reaction
4. Cooling

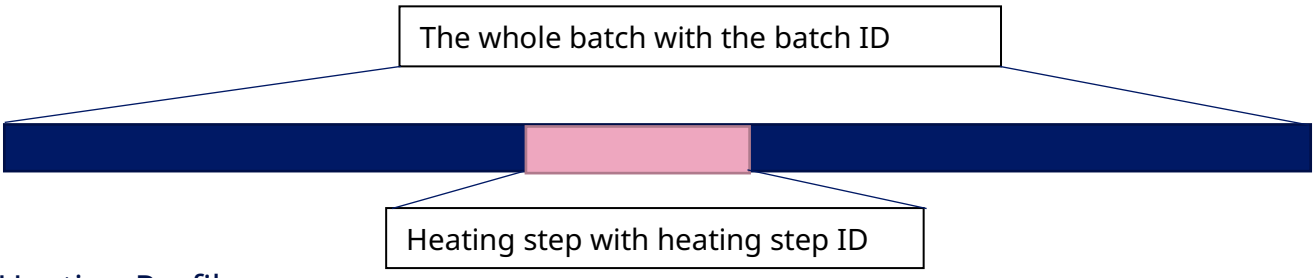
Your colleagues from the production are saying that they are noticing step no.2 – heating is taking longer time to complete, but they are unsure if it is their own imagination. They need you to investigate the issue.

Data

You are given the following data:

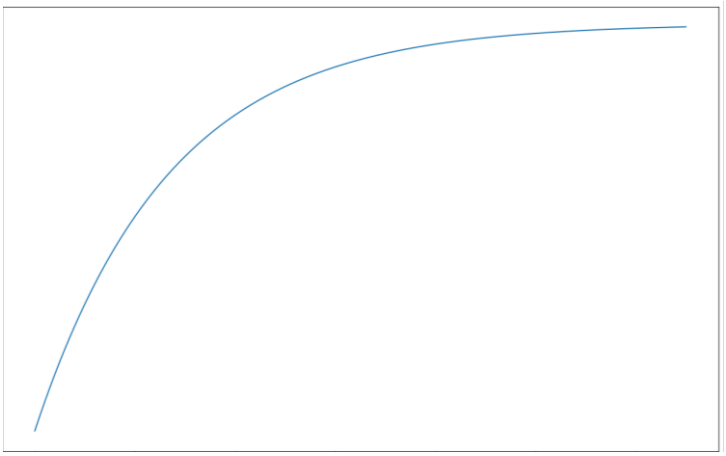
- "TankTemperature" contains the temperature of the tank in any given time. The temperature from the tank is logged every minute.
- "HeatingTime" contains [Start] and [End] of the heating step of interest. Each heating step has an ID given in the [ID] column.
- "BatchID" contains the [Batch_ID] and the [Start] and [End] time of the batch produced

see figure below:



Heating Profile

The Heating profile is shown on the graph below. Tank temperature [°C] on y-axis and time on x-axis:



Challenges/tasks

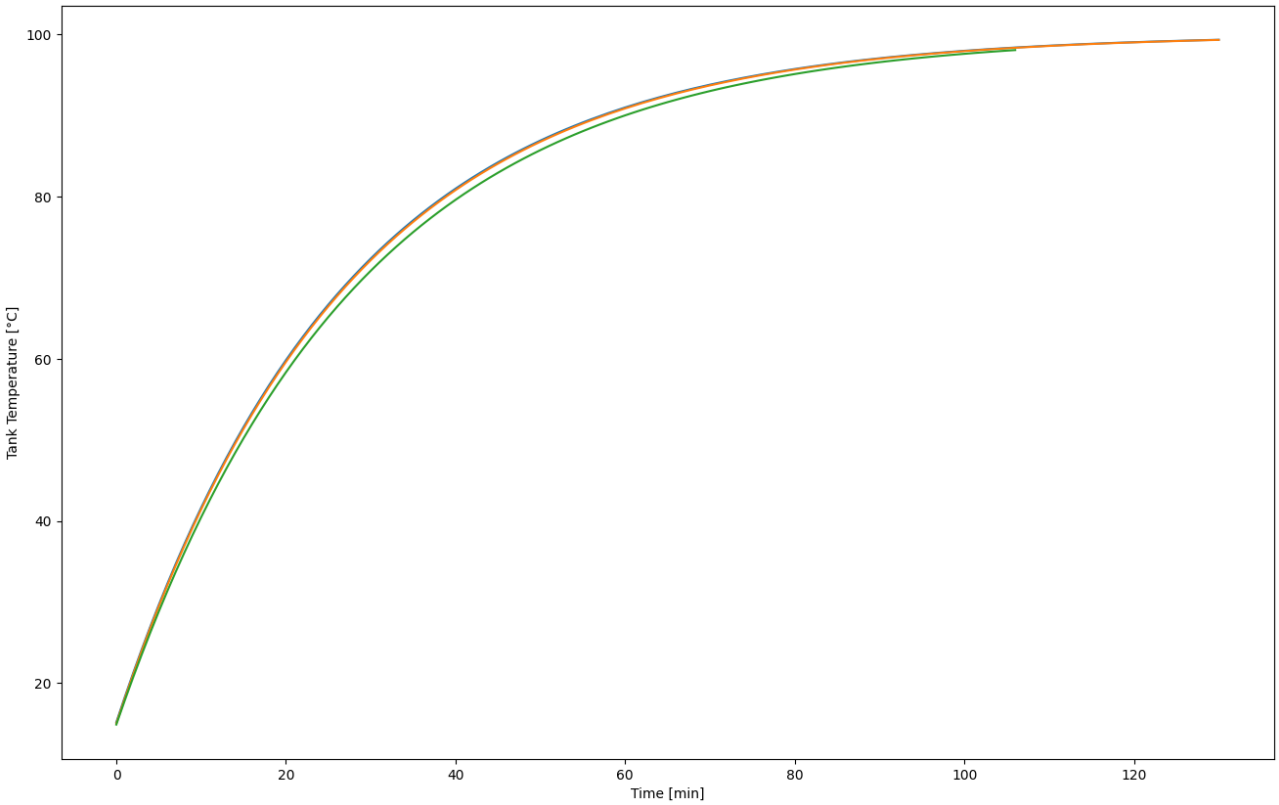
Task 1 – Replacement of batch ID

Replace the heating ID with the Batch ID. At the same time add a timestamp (start time of the batch in the format yyyy-mm-dd) in the beginning of the batch ID. The result should look like this:

“2019-03-23: ACCS-3”

Task 2 – Overlay plots

Your colleagues want the heating profile to be plotted on the top of each other to compare the different batches:



OBS: The graph above only contains the first 3 batches. You need to plot all available batches.

Task 3 – Control chart

You realised it is hard to conclude from the overlay plot. Consequently, you would like to make a control chart instead: Make a control chart where you have the time (in min) it takes to reach 80°C (or above) on y-axis vs batch ID on x-axis.

Task 4 – Model development

The change in temperature in an object can be modelled using Newton's law of heating/cooling:

$$T(t) = T_{source} - (T_{source} - T_{start}) \cdot e^{-\alpha \cdot t}$$

where T_{source} (in our case is 100°C) and T_{start} is the temperature of the heating source and starting temperature of the object, respectively. α is a constant.

Develop a model using Newton's law of heating for the heating step. Use the batch data that takes the longest time to each 80°C.

OBS! you are welcome to use any other models you find fit.

Task 4 – Model Application

There has been a breakdown in the production during the heating step, and they need to figure out how much longer they need to stay. The tank temperature is currently 50°C and it must reach 99°C before the operator can leave. Use the model to estimate the time it takes to reach 99°C.