 USN/TNM/EIK

Report for assignment: Programming a simulator of a heated tank in Python

Course: FM1220-1 Automatic Control

Date: 17.09.2021

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# Calculation of the static operating point

Calculate from the model the constant power, P0, needed to bring the temperature to a constant value of 25 deg C.

## Solution

The constant power required to bring the temperature to a constant value of 25 ℃ is 10,250W as shown in Figure 1‑1.

Text

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Figure 1‑1 Calculation of the operating point.

# Programming and simulation

Program a simulator of the tank heater in Python. The simulator must be implemented with "native" code in a For loop based on the Euler Forward discretization of the model (a built-in simulation function of Python should not be used). You can set the time-step to 1 s. The following variables should be plotted: T, Tin, and T\_env in one subplot, and P in another subplot.  
Assume that the initial temperature is T\_init = 20 deg C. Run a simulation with P = P0 as calculated above. Is the static T the same as specified in task 1 above?

## Solution

Yes, the static temperature, with the power calculated in task 1, gives the same temperature as the one used in the calculation: 25 ℃. Parameters used are shown in (2.1) and plots showing the result can be seen in Figure 2‑1.

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| time\_step=1, start\_time=0, stop\_time=5000, power=10\_250, time\_delay=0 | (2.1) |

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Figure 2‑1 Plots showing liquid temperature moving towards a horizontal asymptote at 25℃.

# Stability of the simulator

Demonstrate that the simulator becomes numerically inaccurate, and possibly unstable, if you select a (too) large simulator time step.

## Solution

The simulator does indeed become unstable upon selecting large time steps. Figure 3‑1 displays the result of simulations with the parameters in (3.1).

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| time\_step=1, start\_time=0, stop\_time=5000, power=10\_250, time\_delay=0 | (3.1) |

Chart, line chart

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Figure 3‑1 Plots showing unstable liquid temperature simulation.

# Time delay

Set the time step to 1 sec. Include a time delay of 60 sec in P. Verify with a simulation that the time delay has been implemented correctly.

## Solution

For this exercise a smaller stop time was selected to exaggerate the time delay. The parameters shown in (4.1) was used and the resulting plot can be seen in Figure 4‑1.

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| time\_step=1, start\_time=0, stop\_time=500, power=10\_250, time\_delay=60 | (4.1) |

Chart, line chart

Description automatically generated

Figure 4‑1 Simulation with time delay.