Assignment 1

Simulation of chip tank with conveyor belt

Simulation requirements

The task is to simulate a chip tank system with a conveyor belt. The simulation is implemented in the Python programming language. The following requirements apply:

- The simulation should run at a time of 1 second and up to 5000 seconds. The starting level in the tile tank is 10 meters, and the tank has a minimum level of 0 meters and a maximum level of 15 meters.
- After a period of time, a leap in the control signal from 50% to 55% shall be introduced, and the calculation of the slope of the ramp will be shown from code and theoretically from the Mathematical Model (see Equation 1).

Mathematical model for tile tank

Equation 1. (Taken from: *Modeling, Simulation and Control*)

$$\rho A h' = w_{in}(t) - w_{out}(t) = K_s u(t-\tau) - w_{out}(t)$$

Euler backward method

Equation 2.

$$h_{k+1} = h_k + T_s h\left(t_{k+1,}\, h_{k+1}\right)$$

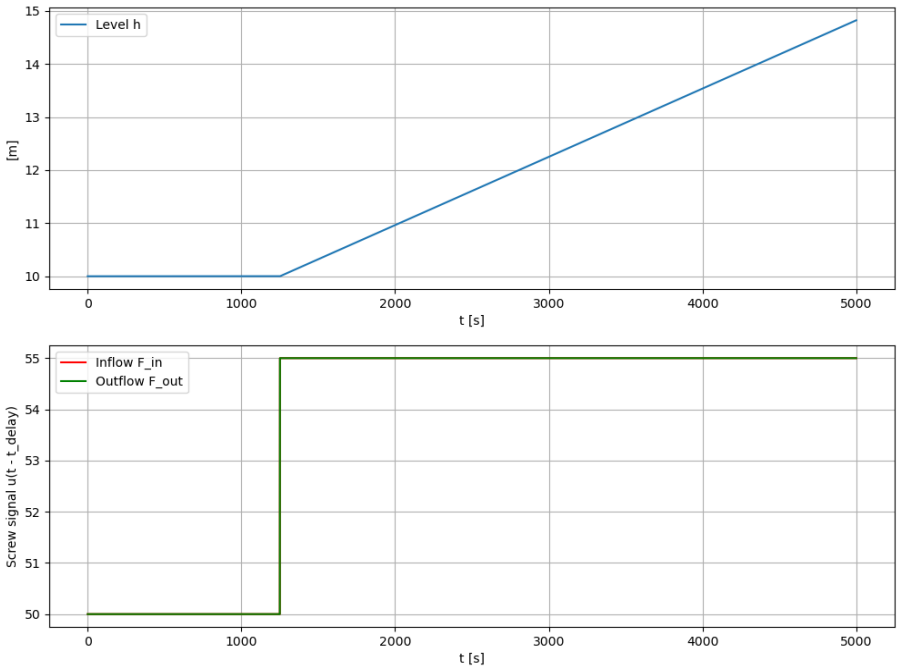
Explanation of the simulation

The code runs the 5000 simulation and measures the height level of the chip tank for each simulation. The calculation of the derivative occurs for each simulation and is added to the previously measured level. This is known as the Euler backward method (see equation 2).

The results of the simulation

After performing 5000 simulations, two graphs were produced. The top graph shows the height level of the tank. The level is constantly 10 meters up to 1000 seconds, here the control signal is

50% that can be seen on the bottom graph. After 1000 seconds, a leap has been made on the control signal from 50% to 55%. The leap does not change the altitude level of the tank once the time is 1000 seconds as expected, because it is delayed by 250 seconds. The leap on the control signal is seen in the bottom graph.



Slope

The slope of the ramp that is in the top graph can be found by taking the difference of the height values from when the when the ramp starts at time 1250 seconds up to 5000 seconds and then taking the average.

Code for finding the slope:

```
slope = np.diff(h_array[1250:5003]).mean()
print(f'Stigningstallet = {slope}')
```

Answer printed out in the Python console:

```
Stigningstallet = 0.0012863269857613024
```

The slope from the model is given from the mathematical model (see Equation 1), solved for the derivative of the height level in the tank.

$$h' = \frac{K_s u(t-\tau) - w_{out}(t)}{\rho A} = \frac{\left(0.5 \frac{\frac{kg}{s}}{\%}\right)(55\%) - \left(25 \frac{kg}{s}\right)}{\left(145 \frac{kg}{m^3}\right)(13.4\ m^2)} = 0{,}001286670097786\ m$$

The theoretical slope from the model is approximately equal to the slope calculated in the code.