PDC Home Exercise 17/4: Tuning of a PID controller based on frequency response

The figure to the right illustrates a heat exchanger and its control system. The dynamics of the relevant components are given by the following transfer functions:

\[
T(s) = \frac{1.25 \, ^\circ\text{C\,min}}{w_g(s) = \frac{(15s + 1)(4s + 1)}{kg}},
\]

\[
w_g(s) = \frac{(15s + 1)(4s + 1)}{kg},
\]

\[
p(s) = \frac{0.4 \, \text{kg}}{2s + 1 \, \text{kPa\,min}}, \quad \frac{p_T(s)}{T(s)} = \frac{0.1 \, \text{kPa}}{s + 1 \, ^\circ\text{C}}.
\]

Tune the PID controller "TC" by Åström’s and Hägglund’s frequency-response based method.

*Hint:* The required parameters \( K_{c,\text{max}} \) and \( P_c \) (or \( \omega_c = \frac{2\pi}{P_c} \)) can be found by doing an experiment with a P controller as described in the lecture slides. An alternative is to use the substitution \( s = j\omega \) in the characteristic equation for the closed-loop system using a P controller with the gain \( K_c \). The solution that satisfies the characteristic equation gives the stability limit \( \omega = \omega_c > 0 \) and the corresponding \( K_c = K_{c,\text{max}} \).