Control of a Laboratory Distillation Column with Methanol-Water Mixture

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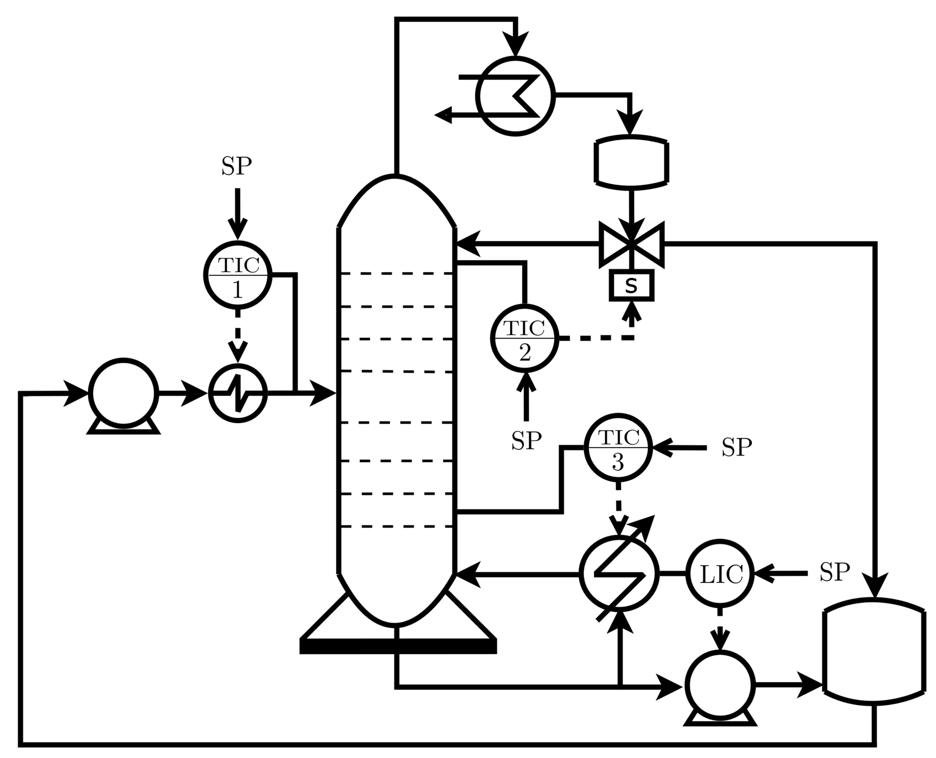
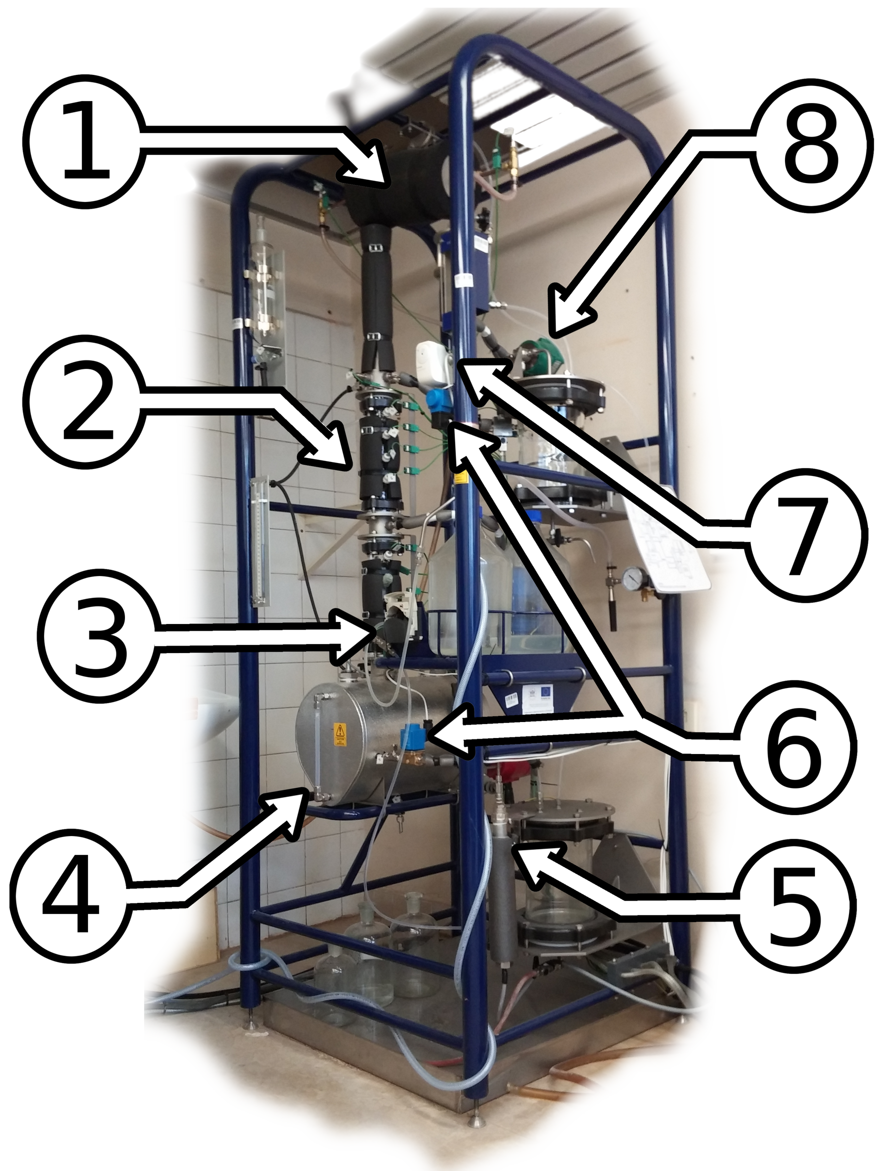
Goals

Distillation columns are essential units in chemical engineering used for separating mixtures into their individual components. They operate based on the principle differences in volatility between the components of a mixture. Our goal is to control a laboratory distillation column with methanol-water mixture.

P&ID Scheme

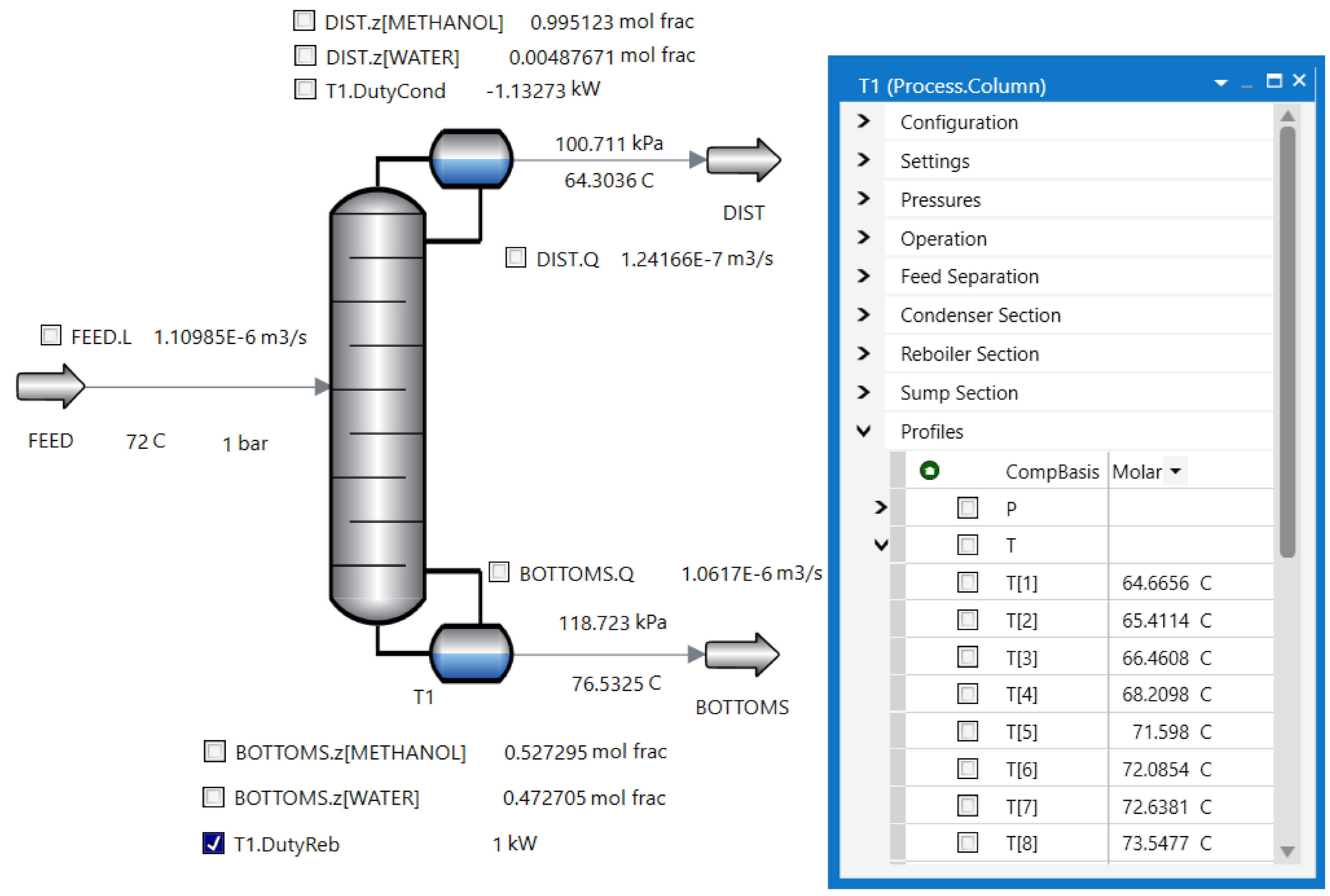


Laboratory Plant



1 - Condenser, 2 - Stages of the column, 3 - Feed pump, 4 - Reboiler, 5 - Feed preheater, 6 - Product valves, 7 - Cooling water valve, 8 - Reflux valve

Steady-State Model in AVEVA Process Simulation



PI Controller Tuning

Plant model - transfer function (TF):

$$G(s) = \frac{\text{outputs } Y(s)}{\text{inputs } U(s)} = \frac{K}{Ts+1}e^{-\tau s}$$

TF (bottom temperature and reboiler duty):

$$G(s) = \frac{T_8(s)}{Q_B(s)} = \frac{7.5}{8.3s+1}$$

TF (top temperature and reflux ratio):

$$G(s) = \frac{T_1(s)}{R(s)} = \frac{-0.1142}{112.1s+1}$$

Control law (PI controller):

$$u(t) = K_p(w(t) - y(t)) + \frac{K_p}{T_i}\int_0^t w(t) - y(t)\,\mathrm{d}t$$

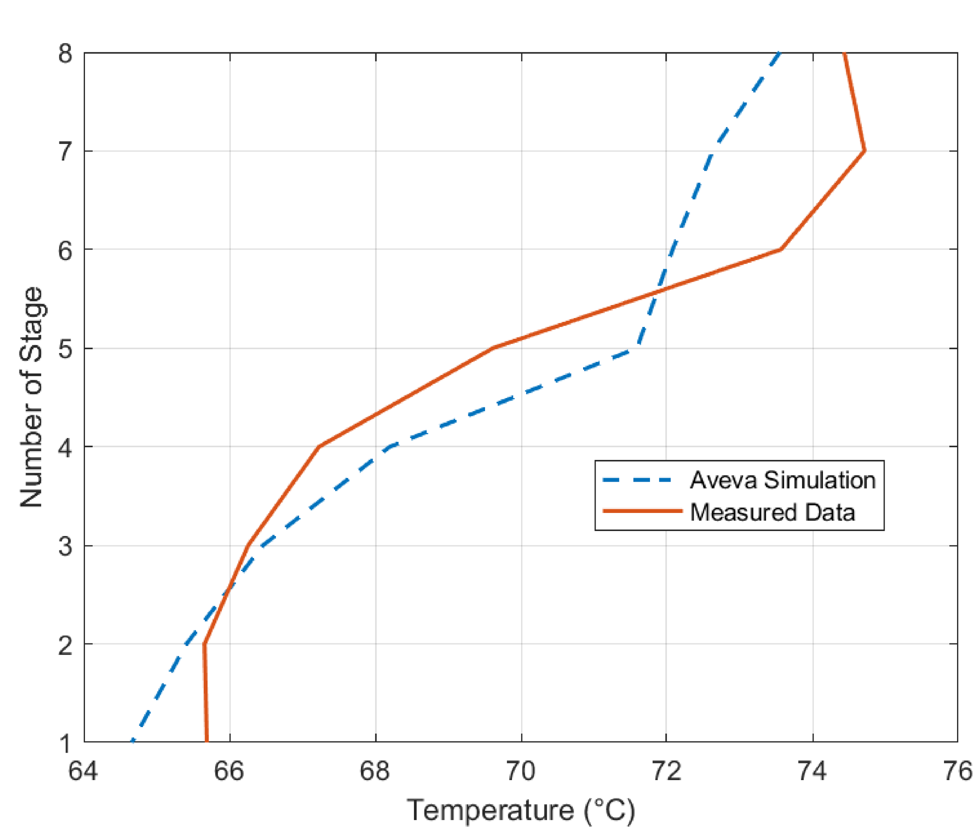
Proportional gain:

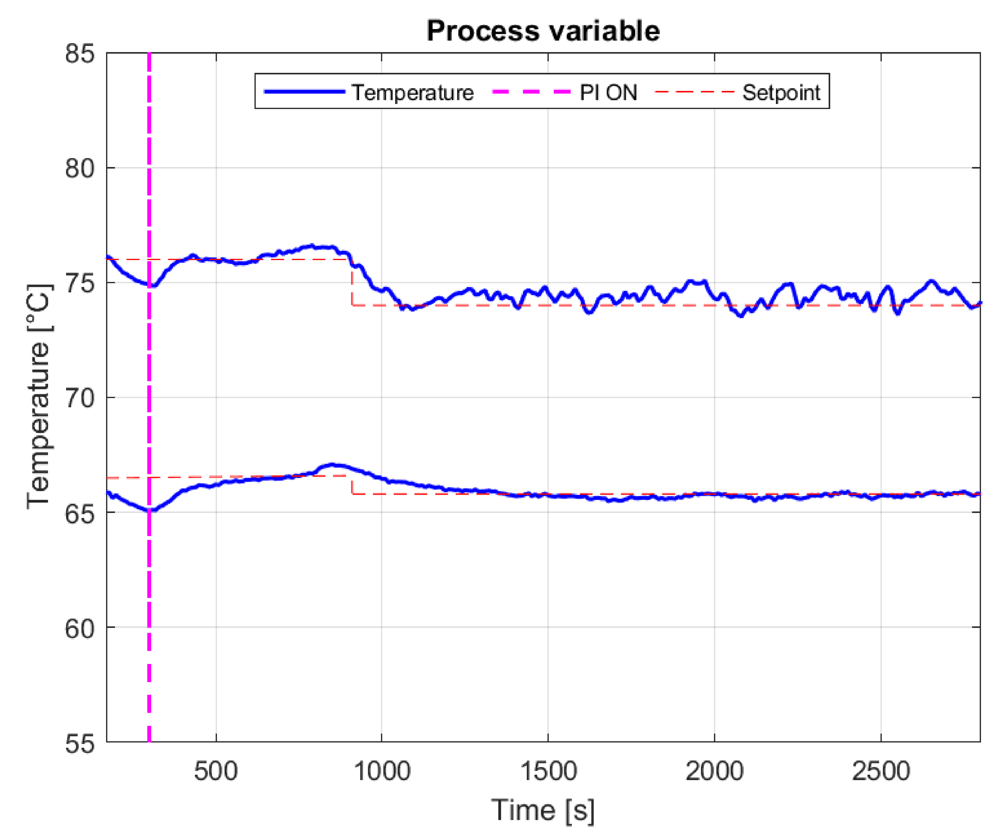
$$K_p = \frac{T}{K(T_c + \tau)}$$

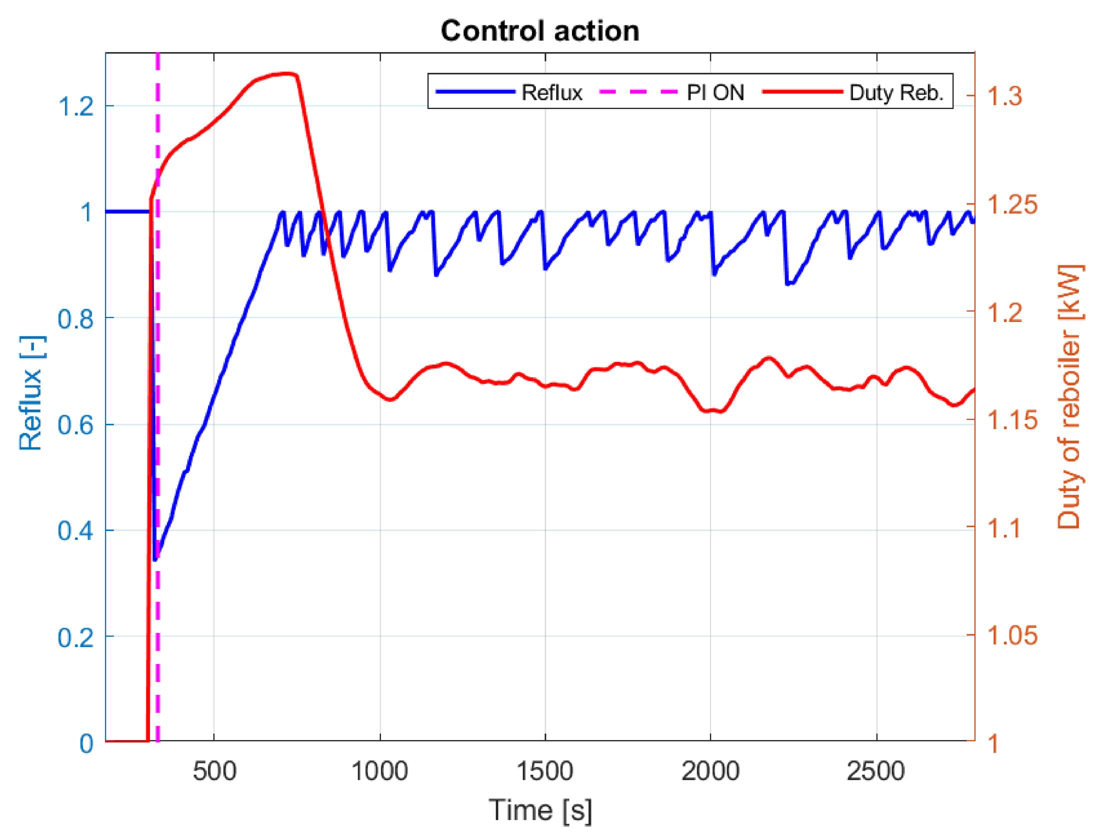
Integral time constant:

$$T_i = \min[T, 4(T_c + \tau)]$$

Results







Conclusions

The experimental column control exhibited promising results, with stable temperature and composition profiles very similar to the strady-state model. This highlights the efficacy of the control algorithm in optimizing process parameters and ensuring high-quality product output.

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