TTK4210 Advanced Control of Industrial Systems, Exercise 6

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1 Introduction

Skriv introduksjon med presentasjon av problemstillingen

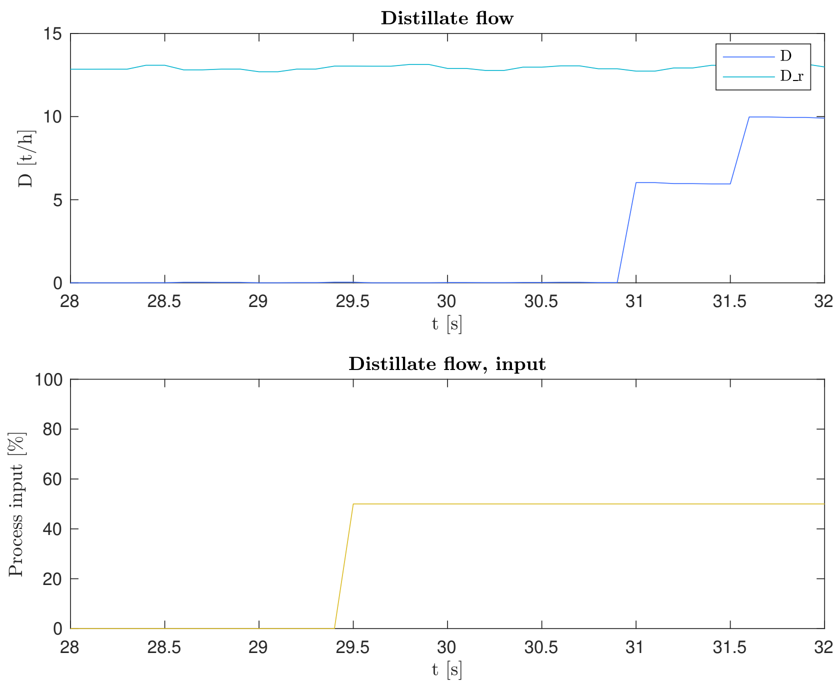

Fig. 1: Open-loop step response of D

2 Tuning secondary controllers

The secondary controllers were tuned individually using the SIMC method for PI controllers. A step in process input with an amplitude small enough not to cause problems in other parts of the system was used for all the secondary controllers, controlling the states D, L, B, V and p.

In short, the method can be summarized as follows

Legg til kilde, regtek-boka

1. Fit the step response to a first order model. This means finding time delay τ, slope $k' = \frac{dy/dt}{\Delta u}$ and time constant T_1 from the plot of the step response.

2. To achieve the desired time constant T_L, use the PI controller parameters $K_p = \frac{1}{k'}\frac{1}{\tau + T_L}$, $T_i = \min(T_1, 4(\tau + T_L))$.

The data from these experiments can be seen in figures 1, 2, 3, 4 and 5. The accuracy of the simulations are clearly not sufficient for fitting a first order model, but inspecting the order of magnitude of the gains and time

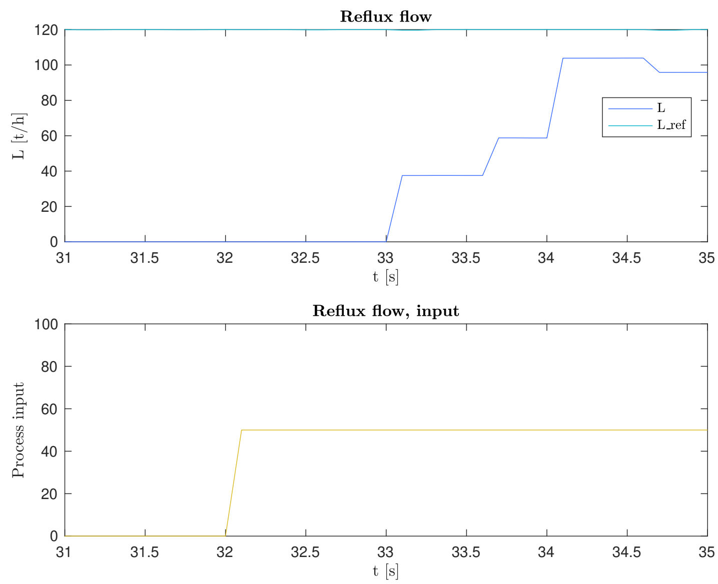

Fig. 2: Open-loop step response of L

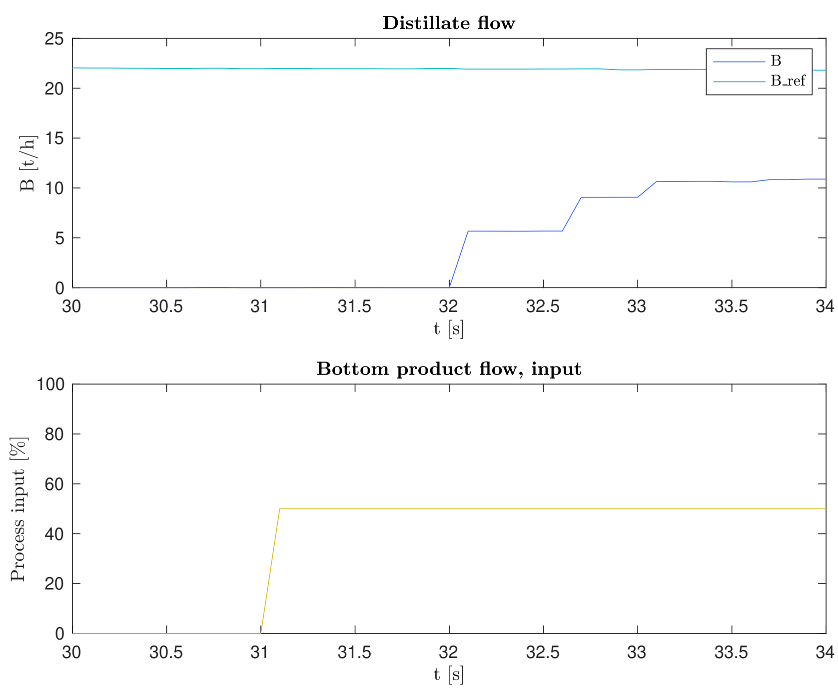

Fig. 3: Open-loop step response of B

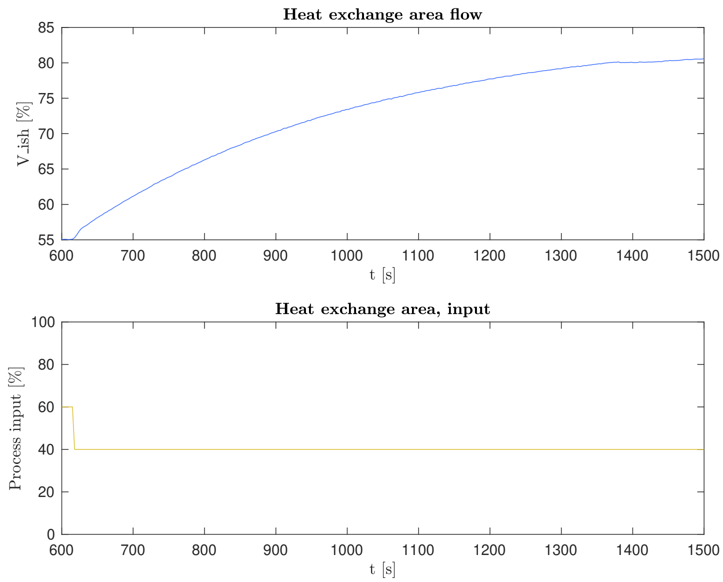

Fig. 4: Open-loop step response of heat exchanger area, related to V

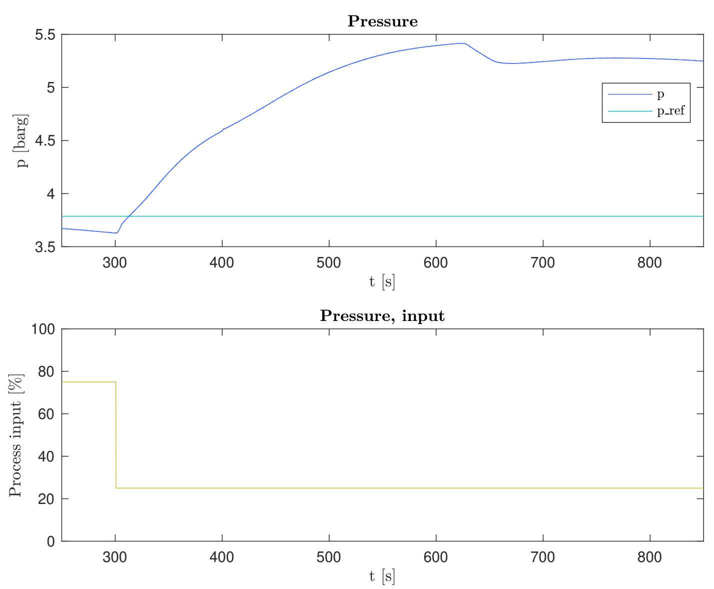

Fig. 5: Open-loop step response of p

	τ	T_1	$\frac{dy}{dt}$	Δu	k'	T_L
D	1,0s	0,4s	14,3	50%	28,6	2s
L	1,0s	1,0s	47,5	50%	95,0	2s
B	1,0s	0,6s	10,0	50%	20,0	2s
V	≈ 0	400s	0,028	20%	0,14	10s
p	≈ 0	200s	0,088	50%	0,18	10s

Table 1: Identified parameters for inner loop

	K_p	T_i	G_{SIMC}	G_{final}
D	0,0035	0,4s	0,42	0,42
L	0,0018	1,0s	0,22	0,22
B	0,0083	1,0s	1,0	0,30
V	0,71	40s	86	86
p	0,57	20s	68	30

Table 2: PI controller parameters for inner loop

constants is a good start. An attempt at making sense of these sizes is shown in table 1. In addition to this, a desired time constant T_L is shown in the rightmost column. For a quick response, choosing $T_L = 0,3\tau$ is suggested in [?]. Some simple trial and error showed that this lead to unfortunate between control loops, especially the controllers for D and L. Due to this, $T_L = 2\tau$ was chosen for the three fastest control loops. Since the time delay was hard to make a meaningful reading of for the other systems, a somewhat arbitrary choice of $T_L = 10s$ was chosen for these systems. Like all the other parameters, these are not absolute choices, but a good starting point.

After calculating the SIMC controller values, some qualitative tuning was needed. Here, the integral times (which could be read decently precisely) were fixed. The resulting one degree of freedom made tuning easier, and the results of this tuning is shown in table 2, together with the values from the SIMC method (which were the basis for the second round of tuning). A column showing the scaled gain $G = K_p \frac{(y_{\max} - y_{\min})}{(u_{\max} - u_{\min})}$, which is the value implemented in K-spice, is also shown. The final controller gains are also given in this variable, since the parameters were changed directly in the K-spice panel. Note that T_i in the p control loop was changed from 40s to 20s in the final tuning.

Legg til noe om at resten av sys- temet bare var i til-

3 Level controllers

3.1 System identification

Dette

3.2 Controller tuning

Dette

4 Composition controllers

4.1 System identification

Dette

4.2 Controller tuning

Dette