Lab 01: Feedforward control

CHEN4011: Advanced modeling and Control

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1 Objectives

i. To design a feedforward controller in combination with a feedback controller

ii. To evaluate the performances with and without feedforward controller in the cases of setpoint tracking and disturbance rejection.

iii. To develop Matlab Simulink model for the combined feedforward-feedback control strategy

2 Process information

The transfer functions for the process and disturbance are

$$\begin{aligned} \text{Process: } G_p(s) &= \frac{10\exp(-2s)}{(10s+1)(1.5s+1)} \\ \text{Disturbance: } G_d(s) &= \frac{-8\exp(-3s)}{20s+1} \end{aligned} \tag{1}$$

3 Simulation

Develop the Simulink models for the feedback control only and feedforward-feedback control strategies. Design the feedback (PID) controller using the PID tuner app. Also, design the feedforward controller using the idealized method.

Evaluate the control performance for:

i. Setpoint tracking

ii. Disturbance rejections for both input and output disturbances

A second-order model can be reduced using the Skogestad's half rule (Skogestad 2003) given by Equation 2.

$$G(s) = \frac{K_p e^{-\theta_p s}}{(\tau_1 s+1)(\tau_2 s+1)} \cong \frac{K_p e^{-\theta_e s}}{\tau_1 s+1} \text{ where } \tau_1 > \tau_2 \text{ and } \theta_e = \theta_p + \tau_2 \tag{2}$$

4 Report Format

1) Show the MATLAB Simulink Model of the combined feedforward-feedback control strategy. Briefly explain the model. [2 marks]
2) Show the PID controller and feedforward controllers (using idealized method). [2 marks]
3) Compare and comment on the control performances (setpoint tracking and disturbance rejection) of the two control strategies: (1) feedback control only, and (2) combined feedbackfeedforward control (idealized method). Show the plots of the controlled variable under the two different control strategies. [6 marks]

i. Does the implementation of the feedforward controller improve the setpoint or disturbance rejection performance?
ii. Will the control system remain stable when subjected to the 10% modelling errors?
iii. Which feedforward controller that gives the best result, based on the unified or idealized method?

References

Skogestad, Sigurd. 2003. "Simple Analytic Rules for Model Reduction and PID Controller Tuning." *Journal of Process Control* 13 (4): 291–309. https://doi.org/10.1016/S0959-1524(02)00062-8.