

This problem set attempts to create a realistic context for obtaining a process model. It then explores how you might use the model. All the operations themselves are straightforward; it's the sense of adapting the formulas to your needs that I want to get across.

Remember what a “process model” is? It's some sort of calculation that allows you to say *something* about how (some part of) the process will operate. Imagine that your process needs controlling, and you want to know how your proposed manipulated variable will affect your controlled variable. Clearly, it would be useful to have a model that relates the two variables, one an input, and the other an output - specifically, you want to determine the transfer function $G_m(s)$. For simple processes, we may obtain $G_m(s)$ by writing conservation equations, etc.; for complicated processes, we may use experimental data to fit parameters in some useful form, such as the FODT.

So, you stepped your valve opening by 10% and measured the sensor reading until it steadied out. You then try to fit

$$\frac{y_s^*(s)}{x_{co}^*(s)} = G_p(s) = \frac{K_p}{\tau s + 1} e^{-\theta s}$$

where the scaled sensor output y_s^* has dimensions of %in and the scaled valve position is the same as the scaled controller output x_{co}^* in %out. Thus you have lumped the valve and sensor in with the rest of the process, because you needn't bother to separate them. Taking care with your data, you get

$$K_p = 0.8 \text{ \%in \%out}^{-1} \quad (K_p = K_v K_m K_s \text{ in our usual nomenclature})$$

$$\tau = 1 \text{ minute}$$

$$\theta = 30 \text{ s}$$

- (1) Find the controller gain K_c (units %out %in⁻¹) that would cause instability for P-mode control.
- (2) Find the largest K_c that satisfies both $GM = 2$ and $PM = 30^\circ$ limits for proportional control.
- (3) Tune the controller for PID operation, using Ziegler-Nichols open-loop tuning. What are GM and PM?
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