CH6605 Process Instrumentation, Dynamics and Control

Dead Time

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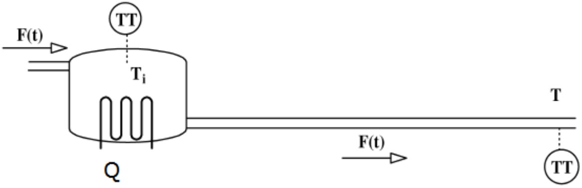
Introduction

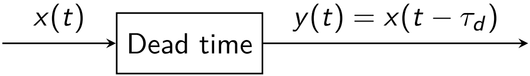
Dead times appear in many processes in industry. They are caused by some of the following phenomena:

- The time needed to transport mass, energy or information.
- The accumulation of time lags in a great number of low-order systems connected in series.
- The required processing time for sensors, such as analysers; controllers that need some time to implement a complicated control algorithm or process.



A heated tank and a long pipe

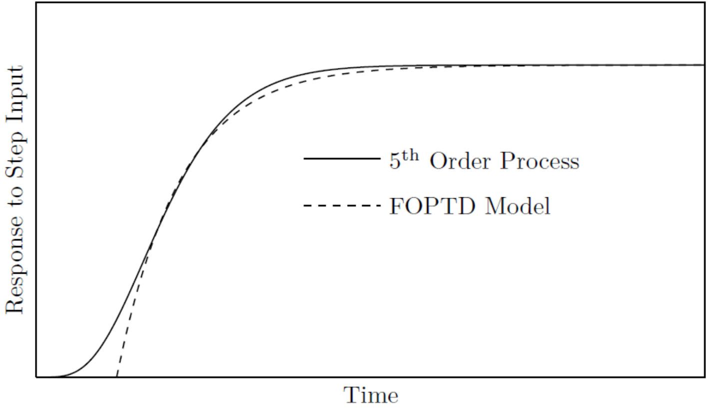
$$\tau_d = \frac{\text{distance}}{\text{velocity}}$$



$$G(s) = \frac{Y(s)}{X(s)} = e^{-\tau_d s}$$

FOPDT

- The dynamic response of self-regulating processes can be described reasonably accurately with a simple model consisting of process gain, dead time and lag (time constant). The process gain describes how much the process will respond to a change in controller output, while the dead time and time constant describes how quickly the process will respond.


5th Order Process
FOPTD Model
Response to Step Input
Time

Systems with order higher than one, can be represented by

$$G(s) = \prod_{i=1}^{n} G_i(s) = \frac{K}{\prod_{i=1}^{n}(\tau_i s + 1)}$$

It can be approximated by a first order plus dead time system as

$$G(s) = \frac{K e^{-\tau_d s}}{\tau_1 s + 1}$$

where τ_1 is the dominant time constant, and,

$$\tau_d = \sum_{i=2}^{n} \tau_i$$

e.g.:

$$G(s) = \frac{K}{(5s+1)(3s+1)(0.5s+1)} \approx \frac{K\,e^{-3.5s}}{5s+1}$$

Here,

$$\tau_1 = 5 \quad \text{(the dominant time constant)}$$
$$\tau_d = 3 + 0.5 = 3.5 \quad \text{(the dead time)}$$