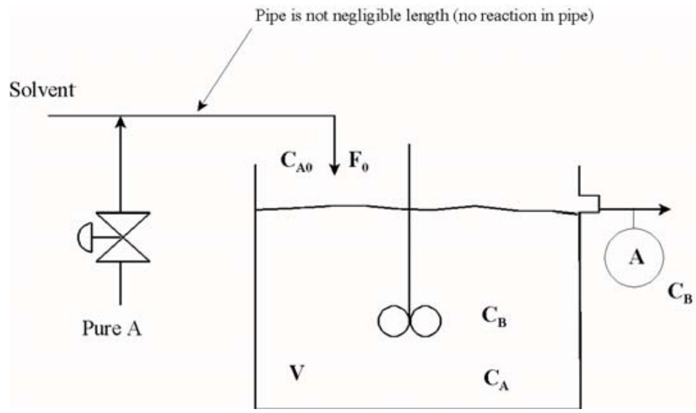
Solutions for Tutorial 11
Digital Control

11.1 Your goal is to control the concentration of B in the reactor effluent by adjusting the pure A control valve.



In Tutorial 9, your determined the tuning for the proposed PID controller based on the process reaction curve in Figure 9.5, with concentrations in mole/m^3 and time in minutes. The results are reported here.

τ = 1.5 (t63% - t28%) = 1.5 (13.4 – 8.56) = 7.2 minutes
θ = t63% - τ = 13.4 – 7.2 = 6.2 minutes
Kp = Δ/δ = 2.5 mole/m3 / 10% open = 0.25 (mole/m3)/%open

PID tuning from the Charts, Figure 9.5 a-c.

$\theta/(\theta+\tau)$ = 6.2/(13.4) = 0.47

KcKp = 0.9	Kc = 0.9/0.25 = 3.6 %open/ (mole/m3)
TI/($\theta+\tau$) = 0.67	TI = 0.67 (13.4) = 9.0 min
Td/($\theta+\tau$) = 0.06	Td = 0.06 (13.4) = 0.80 min

The analyzer to be used for control is not continuous; it provides a new measurement from a sample every 10 minutes. Estimate the tuning for a PID controller.

First, we note that the controller execution period should be not be shorter than the time between new measurement values. This guideline makes sense because there is no advantage to perform feedback without (new) information about the controlled variable.

We will apply the guideline that tuning should be calculated using the modified dead time, which is the sum of the process dead time and one half of the execution period of the controller.

$\theta' = \theta + \Delta t/2 = (6.2 + 5) = 11.2$

PID tuning from the Charts, Figure 9.5 a-c.

$\theta'/(\theta'+\tau) = 11.2/(18.4) = 0.61$	
$K_cK_p = 0.7$	$K_c = 0.7/0.25 = 2.8$ %open/ (mole/m3)
$T_I/(\theta'+\tau) = 0.61$	$T_I = 0.6\ (18.4) = 11.04$ min
$T_d/(\theta'+\tau) = 0.10$	$T_d = 0.1.\ (18.4) = 1.84$ min

We note that the tuning is less aggressive, with a smaller controller gain and larger integral time.

11.2 Suppose that you had an option to purchase a different analyzer with a faster measurement period for the feedback control system in Tutorial Question 11.1. What would be a good sample period?

We would like to have a faster sample period, so that we could improve the feedback control performance. Naturally, a period of 0.0, which is a continuous measurement, would be ideal. Perhaps, a continuous measurement is not possible or is very costly. Therefore, we would like to determine the slowest sampling period that would not significantly affect the control performance.

The textbook provides a guideline that the sampling period should be less than 5% of the t63% of the process reaction curve. An acceptable sampling period is calculated below using the guideline.

Sampling period = $\Delta t = 0.05\ (13.4) = 0.68$ minute

11.3 The textbook gives advantages and disadvantages for distributed computing in a digital control system. Discuss <u>additional</u> advantages and disadvantages.

Advantages

1. Low initial cost, because the smallest system requires limited equipment.
2. Possible to perform control near the sensor and valve, reducing transmission time.
3. Information for processes that are far apart geographically can be used for control and monitoring.

Disadvantages

1. High cost for a single controller compared with an analog system, because the digital system requires more infrastructure.
2. Control at the sensor and valve requires more time to repair, because a person must travel to the local, which could be 100s of meters.

3. More parallel equipment would increase the failure rate, although the impact of each failure would be limited because of the few controllers per computer.
4. Equipment from different vendors is difficult to integrate. The ability to integrate is termed “interoperability”.
5. Loss of the LAN would not directly affect feedback control; however, the operating personnel could not monitor or intervene.
6. The communication between processors must not be at too high a rate to prevent overloading the LAN.

11.4 Search library references and the internet for examples of on-stream analyzers that provide essentially continuous and that provide periodic, sampled measurements. Describe examples of sampled measurements and why these sensors do not provide continuous values.

11.5 Search library resources and the internet for information on new digital technology for sensors, valves and signal transmission between the control room and the field devices (sensors and valves). You can use the following key worlds; smart sensors, digital valve positioners, fieldbus. Briefly describe advantages and disadvantages for (a) digital sensors, (b) digital computation at the valve, and (c) digital signal transmission.