# TKP 4105 Separation Technology

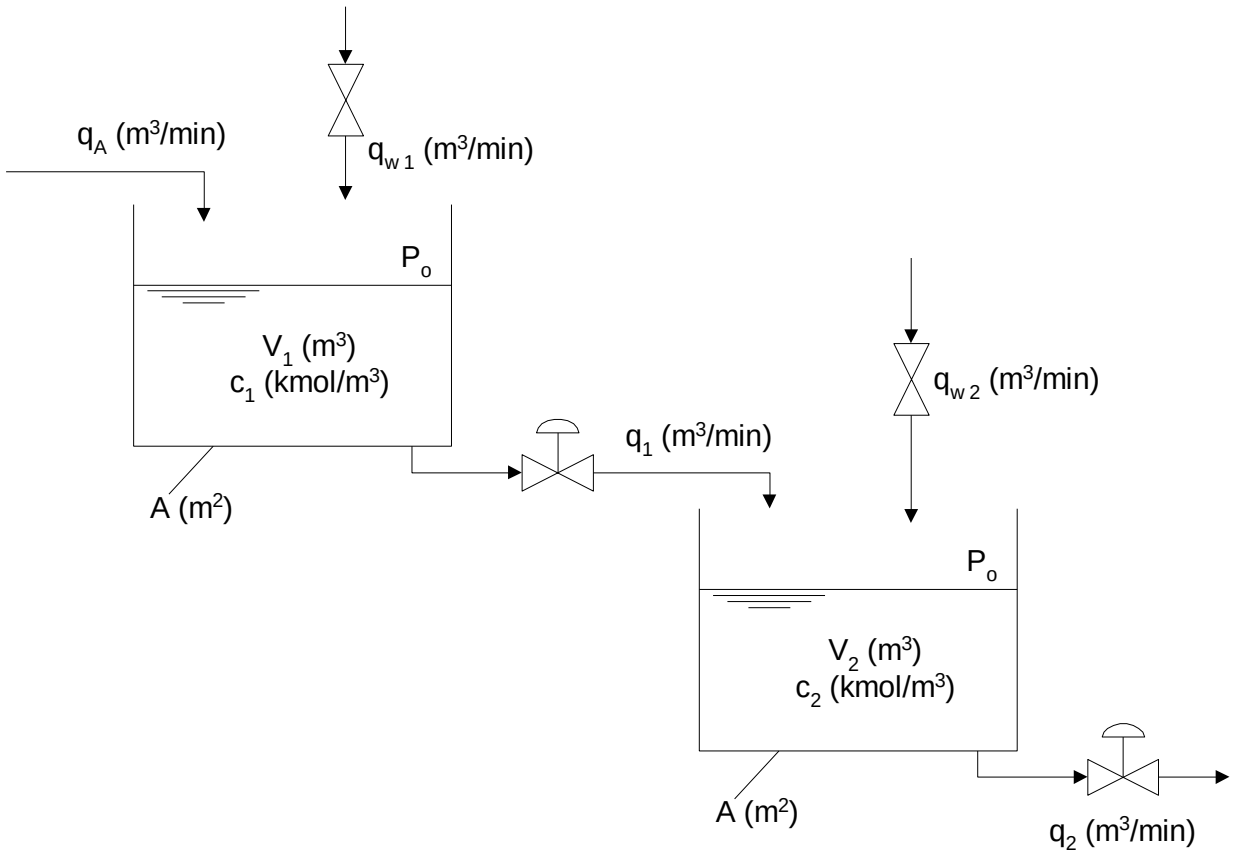
## Exercise Process Control

**Øvingsoppgave 1:**

To blandetanker brukes til å lage svak syre ($q_2$) fra konsentrert syre ($q_4$) og vann ($q_{w1}$ og $q_{w2}$) (se figur 2). I tank 1 skjer det meste av fortynningen, mens tank 2 brukes til finjustering ($q_{w1}$ ~ 10x $q_{w2}$).

Du skal vurdere følgende tre tilfeller:
1) Målinger er $c_1$, $c_2$ samt nivåer
2) Målinger er $c_2$, $q_A$ samt nivåer
3) Som 1), men $q_{w2}$ kan ikke brukes som pådrag

Foreslå reguleringsopplegg
(Merk at $q_{w2}$ er liten og alene ikke vil kunne motvirke store forstyrrelser i $q_A$)




**Problem 1 (English text):**

Two mixing tanks are used to produce a diluted acid ($q_2$) from concentrated acid ($q_4$) and water ($q_{w1}$ and $q_{w2}$), (see figure). The main part of the dilution is done in tank 1, while tank 2 is used to fine tune the dilution to obtain the desired concentration ($q_{w1}$ ~ 10x $q_{w2}$).

Assess the following three cases:
1) $c_1$, $c_2$ and the levels are available as measurements
2) $c_2$, $q_A$ and the levels are available as measurements
3) as in 1), but $q_{w2}$ cannot be manipulated

Suggest a control structure
(Note that $q_{w2}$ is small, so a large disturbances in $q_A$ cannot be compensated by using only $q_{w2}$)

# Exercise Process Control. Solution.

## Problem 1

1.) Control Analysis

- primary goal: tight control on $c_2$.
- keep $c_1$ almost constant, this is where the main part of the dilution takes part
- keep the levels at their setpoints (some deviation allowed)

2.) Variables

Manipulated variables (Inputs): $q_1$, $q_2$, $q_{w1}$, $q_{w2}$,
Outputs: $V_1$, $V_2$, $c_1$, $c_2$
Measurements:
Case 1 and 3: $V_1$, $V_2$, $c_1$ , $c_2$
Case 2: $V_1$, $V_2$, $q_A$ , $c_2$

3.) Process matrix:

Try yourself

4.) Control structure:

In all cases we control the levels using the outflows:
$V_1$ --- $q_1$
$V_2$ --- $q_2$

Case 1:

The pairing is clear since we want to pair variables which are close to each other, see Fig 2. Note that we use a level controller (*LC*) to control the volume *V*, as the variables are proportional by the factor of the cross sectional area of the tank.

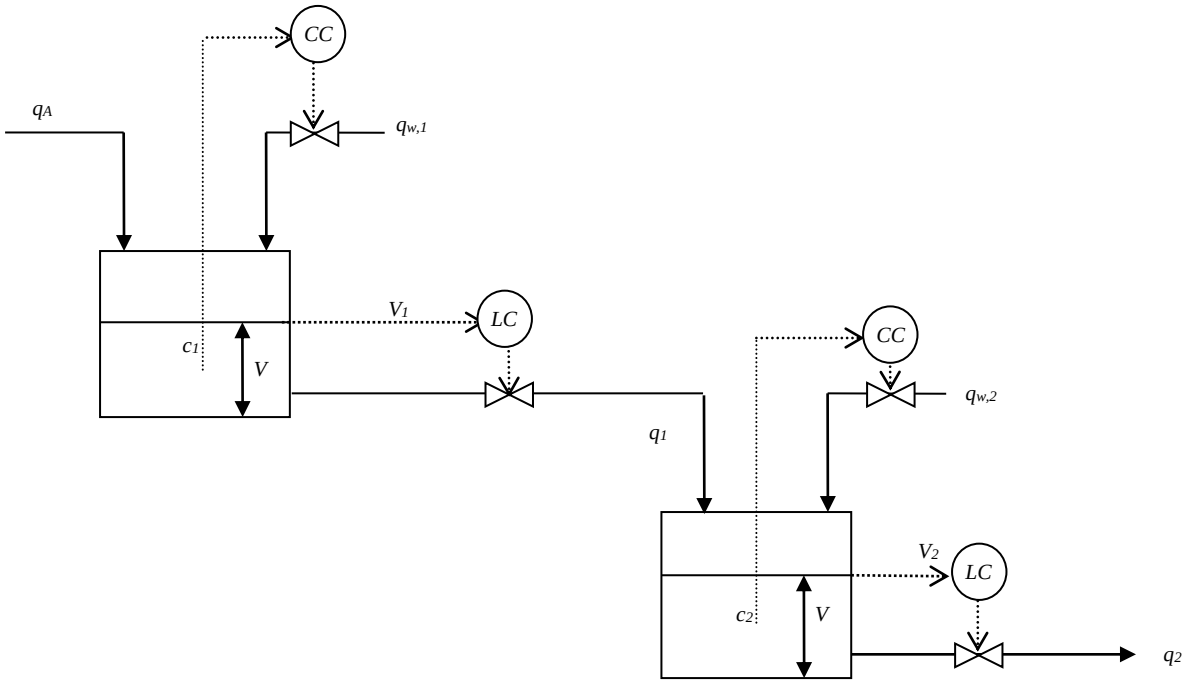



Figure 2. Control structure for case 1

Case 2:

The most important disturbance can be measured, so we use feed-forward control. As $c_2$ then only has small variations, it can well be controlled by $q_{w2}$.

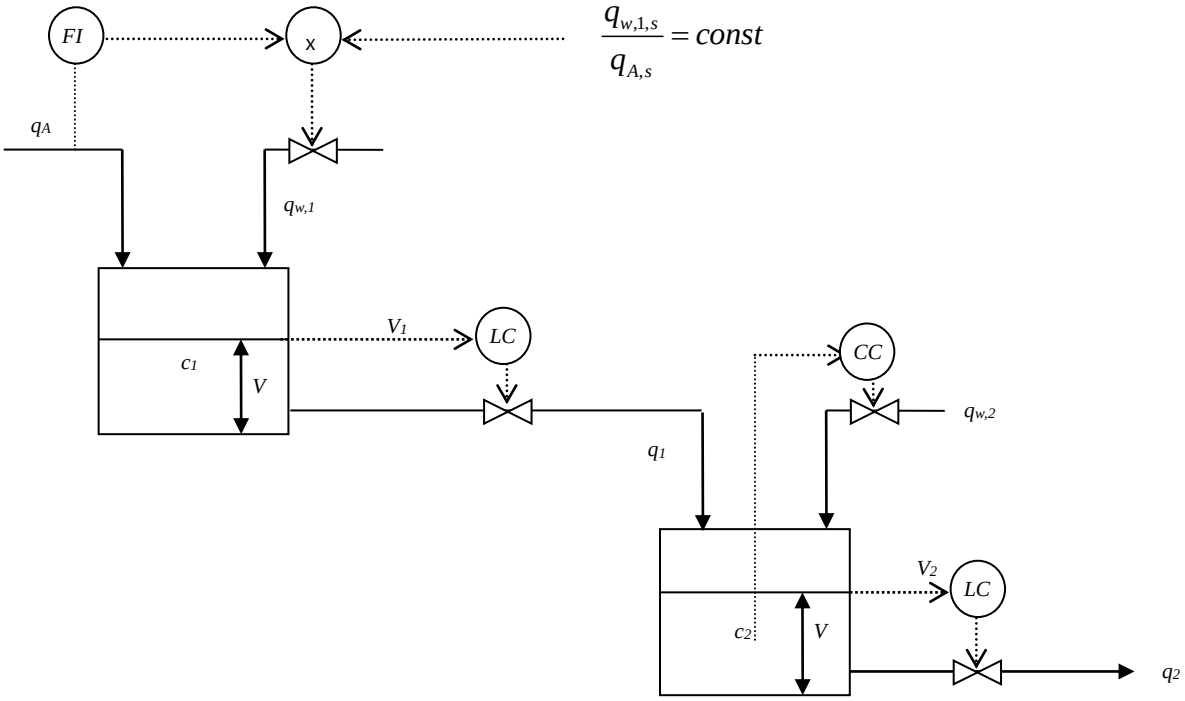



Figure 3. Control structure for case 2

Comments:

- However cascade control could be used for $q_{w2}$ order to get the amount right.
- $R=q_{w1}/q_{w2}$ must be increased/decreased when $q_{w2}$ approaches $q_{w1,max}$ or $q_{w1,min}$
- Remember that $q_{w2}$ is relatively small