Title : Extension to systems with Interacting Units

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Lecture No : 2

Source of information : Chemical Process Control

# Extension to systems with Interacting Units

- ✓ Lets consider system composed of several interacting processing units, since such are the systems encountered in a chemical plant.
- ✓ Best possible configurations for the overall process, we can adopt the following systematic procedure:

1. Divide the process into separate blocks: Every block may contain a single processing unit or a small number of processing units with an inherent, common operational goal.

   Example: condenser and reboiler with distillation column.

2. Determine the degrees of freedom and the number of controlled and manipulated variable for each blocks.

# Extension to systems with Interacting Units

3. Determine all feasible loop configurations for each block. Find best possible loop configurations of all separate block.

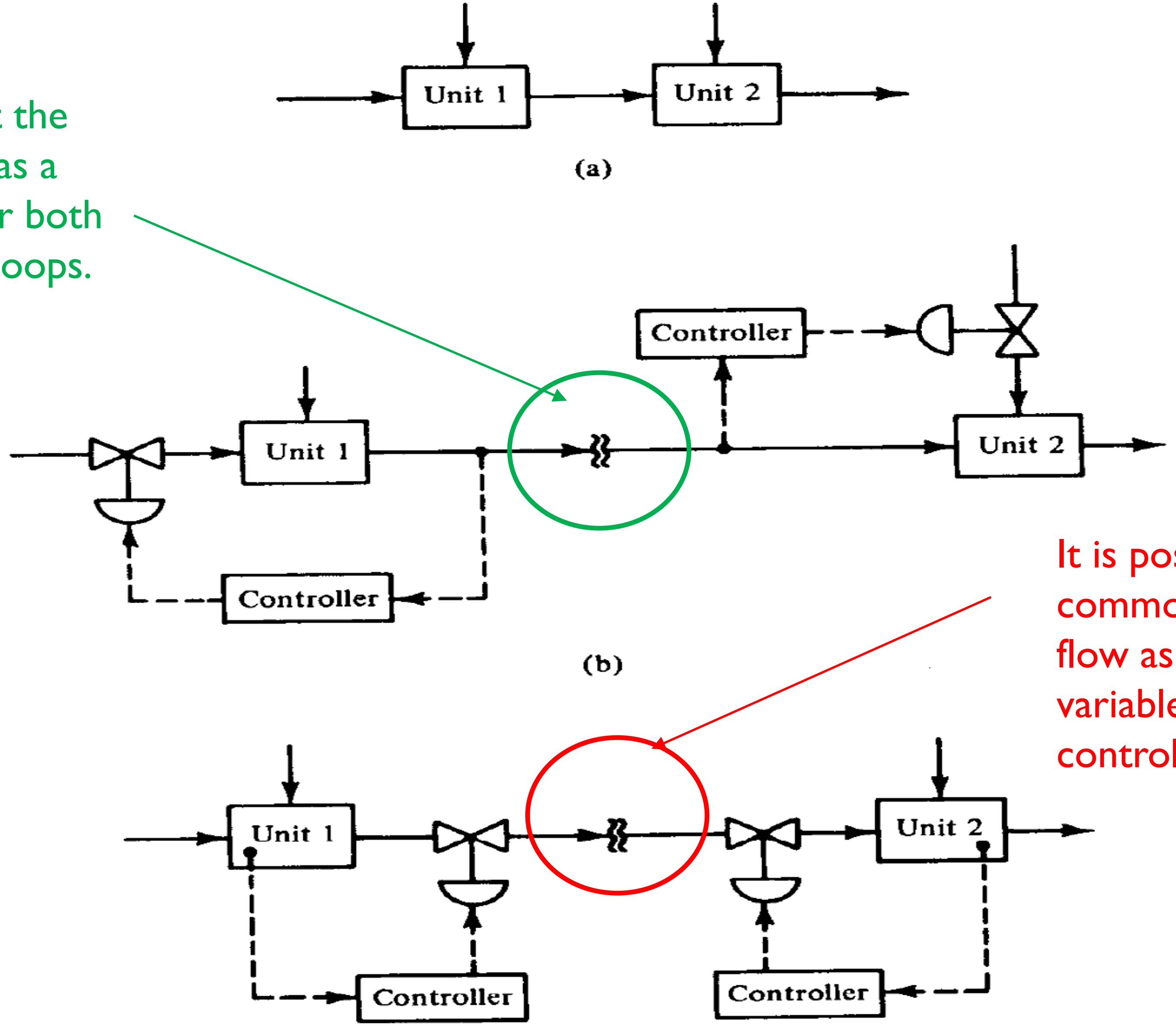
4. Recombine the blocks with their loop configurations.

5. Eliminate conflicts among the control systems of the various blocks. Control configurations resulting in steps 4 usually lead to an over specification of the overall controlled process.

# Extension to systems with Interacting Units

## Example of an over specified system:

It is possible to select the interconnecting flow as a controlled variable for both units but in different loops.

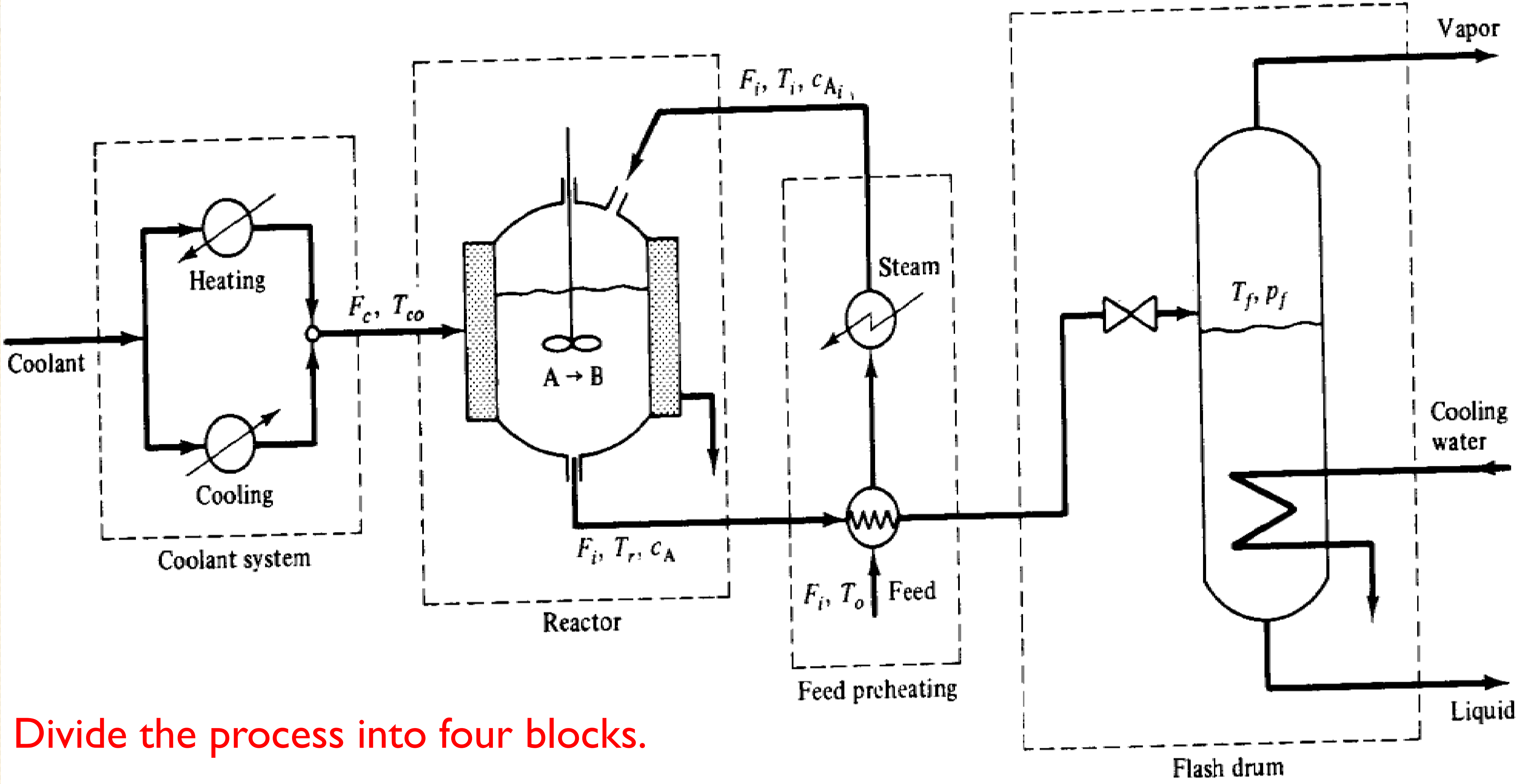



It is possible to have the common interconnecting flow as the manipulated variable in two different control loops.

**Both situations correspond to overspecified systems and lead to conflicts among the control loops.**

**Such conflicts must be erased before we can have feasible control configuration for the overall process.**

# Generate the control loop configuration for a simple chemical process




Divide the process into four blocks.

Determine the degrees of freedom as well as the controlled and manipulated variables for each block. Also generate all possible loop configurations for each block and select the best.

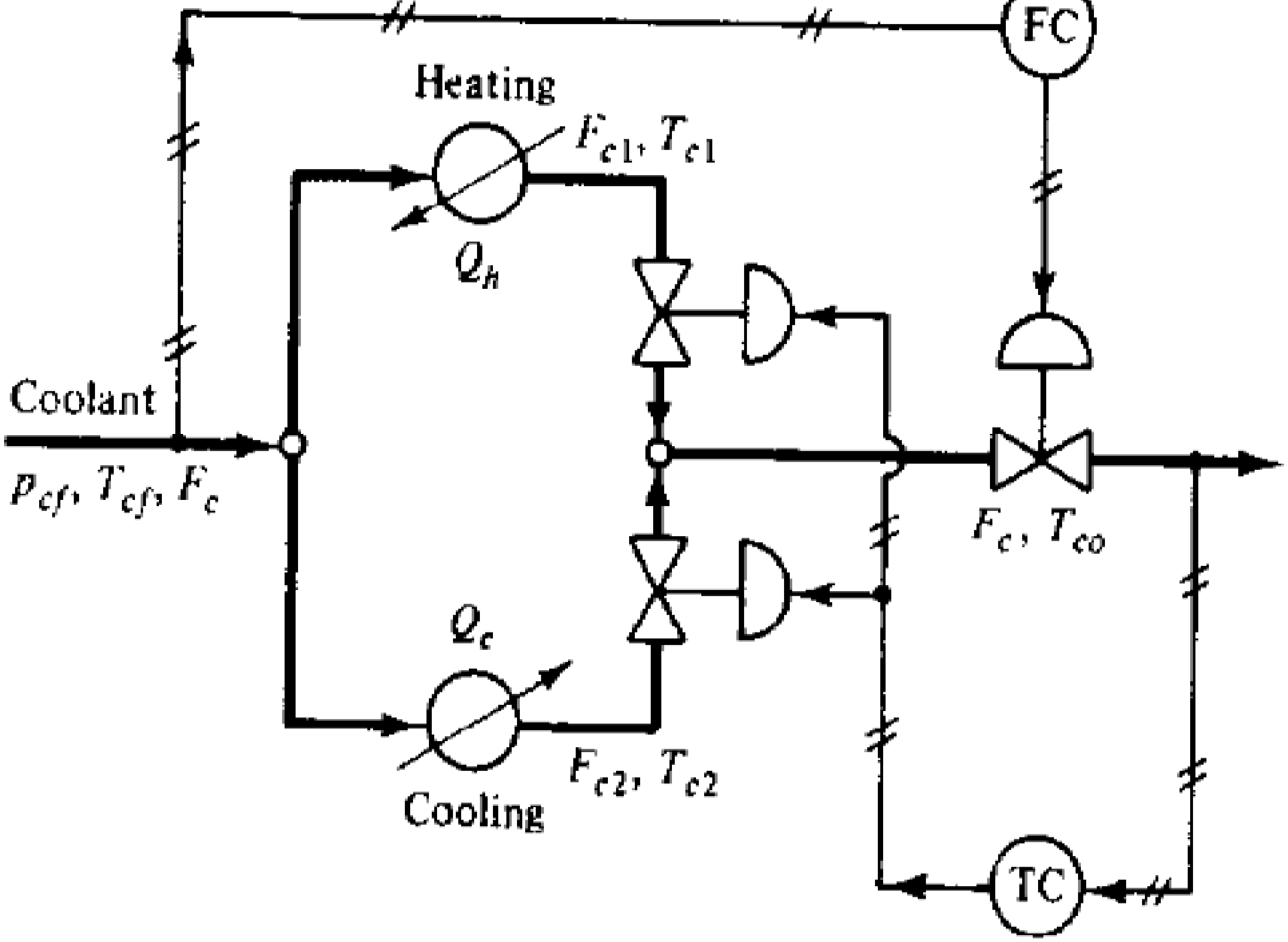
# Coolant system

| | | |
|---|---|---|
| Total number of variables (excluding constant parameters): | 8 | $[p_{cf}, T_{cf}, F_{c1}, T_{c1}, F_{c2}, T_{c2}, F_c, T_{co}]$ |
| Externally specified variables: | 2 | $p_{cf}$ = coolant feed pressure<br>$T_{cf}$ = coolant feed temperature |
| Unspecified variables: | 6 | |
| Number of modeling equations: | 4 | Heat balance on cooling branch<br>Heat balance on heating branch<br>Heat balance on the mixing junction of the two branches<br>Mass balance on mixing junction |
| Number of controlled and manipulated variables: | 2 | |

*Loop Configurations*

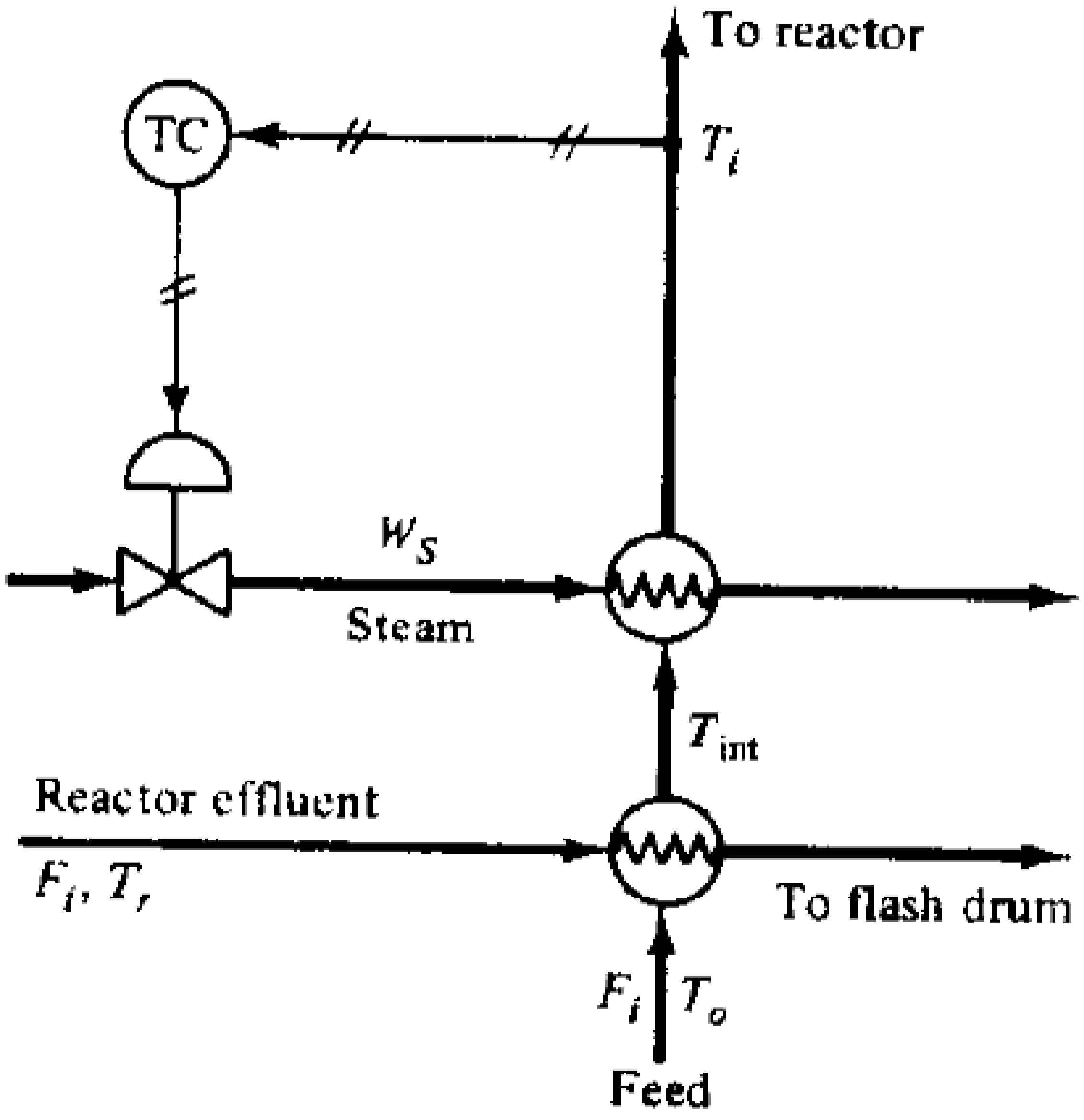
| Configuration | $F_c$ Control by: | $T_{co}$ Control by: |
|---|---|---|
| 1 | $F_c$ | $F_{c1}$ and $F_{c2}$ (split-range control) |
| 2 | $F_{c1} + F_{c2}$ | $F_{c1}/F_{c2}$ |
| 3 | $F_{c2}$ | $F_{c1}$ |
| 4 | $F_{c1}$ | $F_{c2}$ |
| 5 | $F_{c1} + F_{c2}$ | $F_{c1}$ |
| 6 | $F_{c1} + F_{c2}$ | $F_{c2}$ |
| etc. | | |

# Coolant system



# Preheater

- Only one controlled variab Ti. Temperature can be easily controlled by ws manipulated variable.



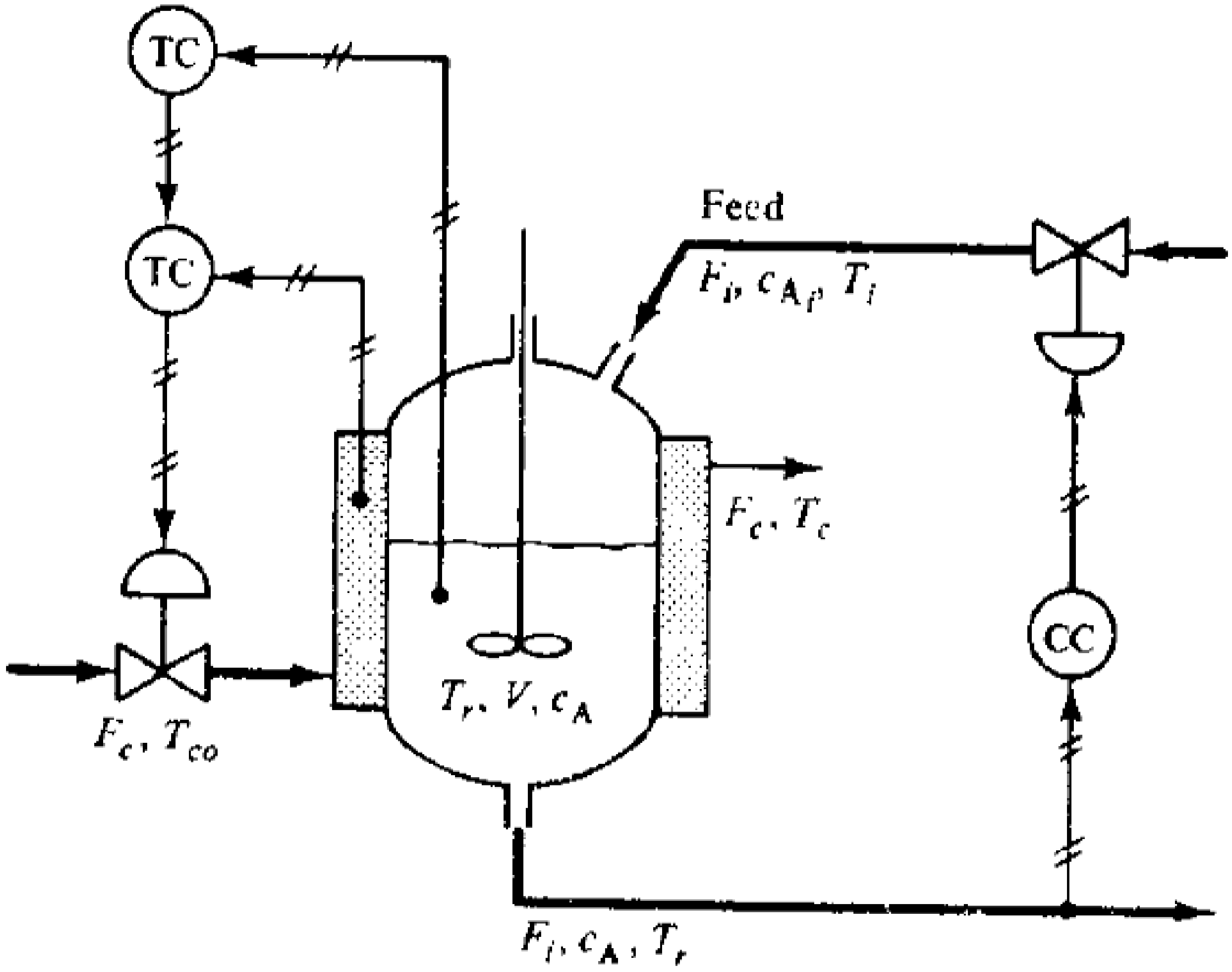
# Reactor

| | | |
|---|---|---|
| Total number of variables (excluding constant parameters): | 9 | [$V$, $T_r$, $c_A$, $c_{A_i}$, $T_i$, $F_i$, $F_c$, $T_c$, $T_{co}$] |
| Externally specified: | 4 | [$F_i$, $c_{A_i}$, $T_i$, $T_{co}$ (or $F_c$)] |
| Unspecified variables: | 5 | |
| Number of modeling equations: | 3 | Component A balance around reactor<br>Energy balance on reacting mixture<br>Energy balance on the coolant in the jacket |
| Number of controlled and manipulated variables: | 2 | |

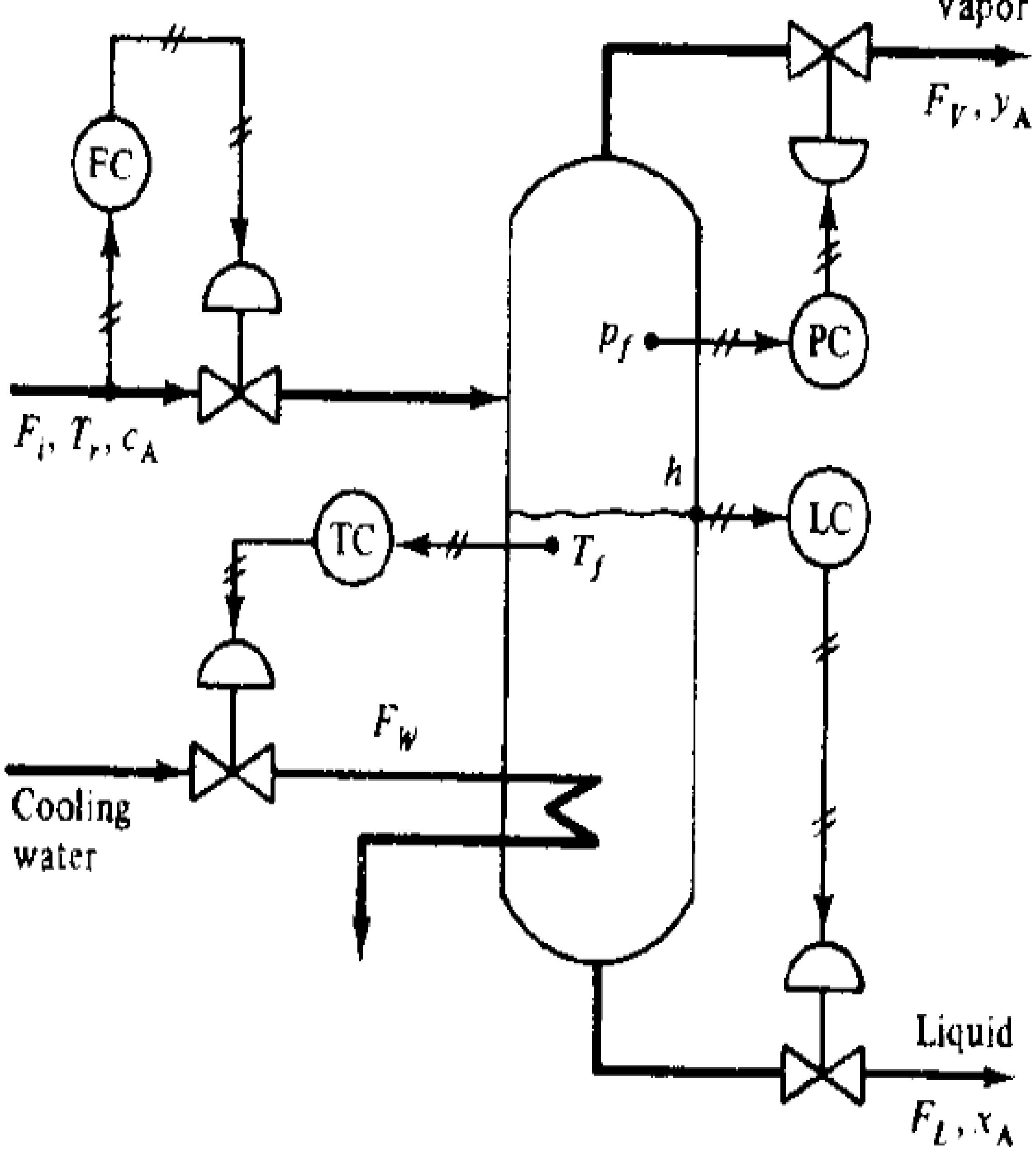
*Loop Configurations*

| Configuration | $c_A$ Control by: | $T_r$ Control by: |
|---|---|---|
| 1 | $F_i$ | $F_c$ (or $T_{co}$) |
| 2 | $F_c$ (or $T_{co}$) | $F_i$ |
| 3 | $F_i$ | $F_c$, with $T_c$ as a secondary measurement in a cascade configuration |

# Rector

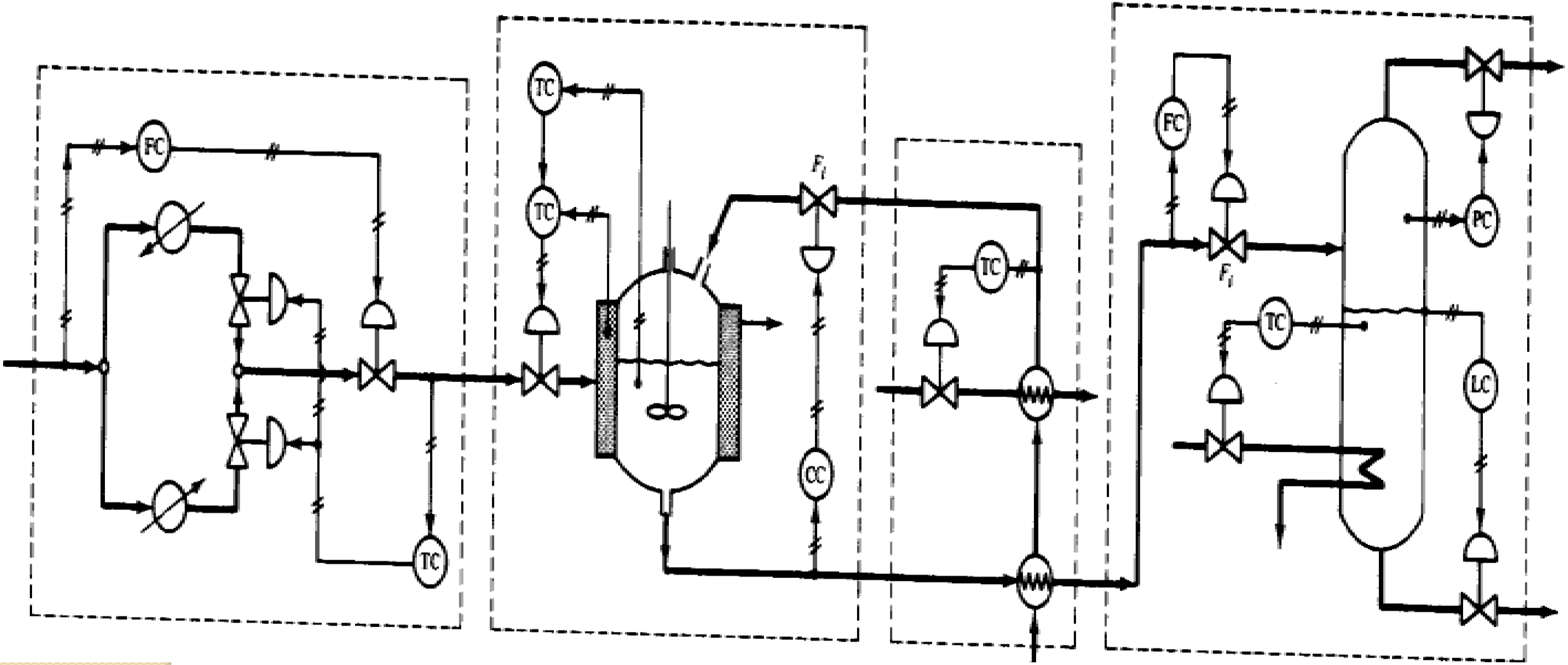


# Flash Drum



Vapor
$F_V, y_A$
FC
PC
$p_f$
$F_i, T_r, c_A$
h
LC
TC
$T_f$
$F_W$
Cooling water
Liquid
$F_L, x_A$

# Chemical Process



# Assignment - 2

1.Assuming that all variables can be measured, how many measurements do you need for the design of a control system with N controlled variables?

- Hard copy submission date (31/3/2020).
- Phone number : 7096850097

# Thank you