Ratio Control

- Ratio control is a special type of feedforward control that has had widespread application in the process industries.
- The objective is to maintain the ratio of two process variables as a specified value.
- The two variables are usually flow rates, a manipulated variable *u*, and a disturbance variable *d*.
- Thus, the ratio $R = \frac{u}{d}$ is controlled rather than the individual variables.

Typical applications of ratio control

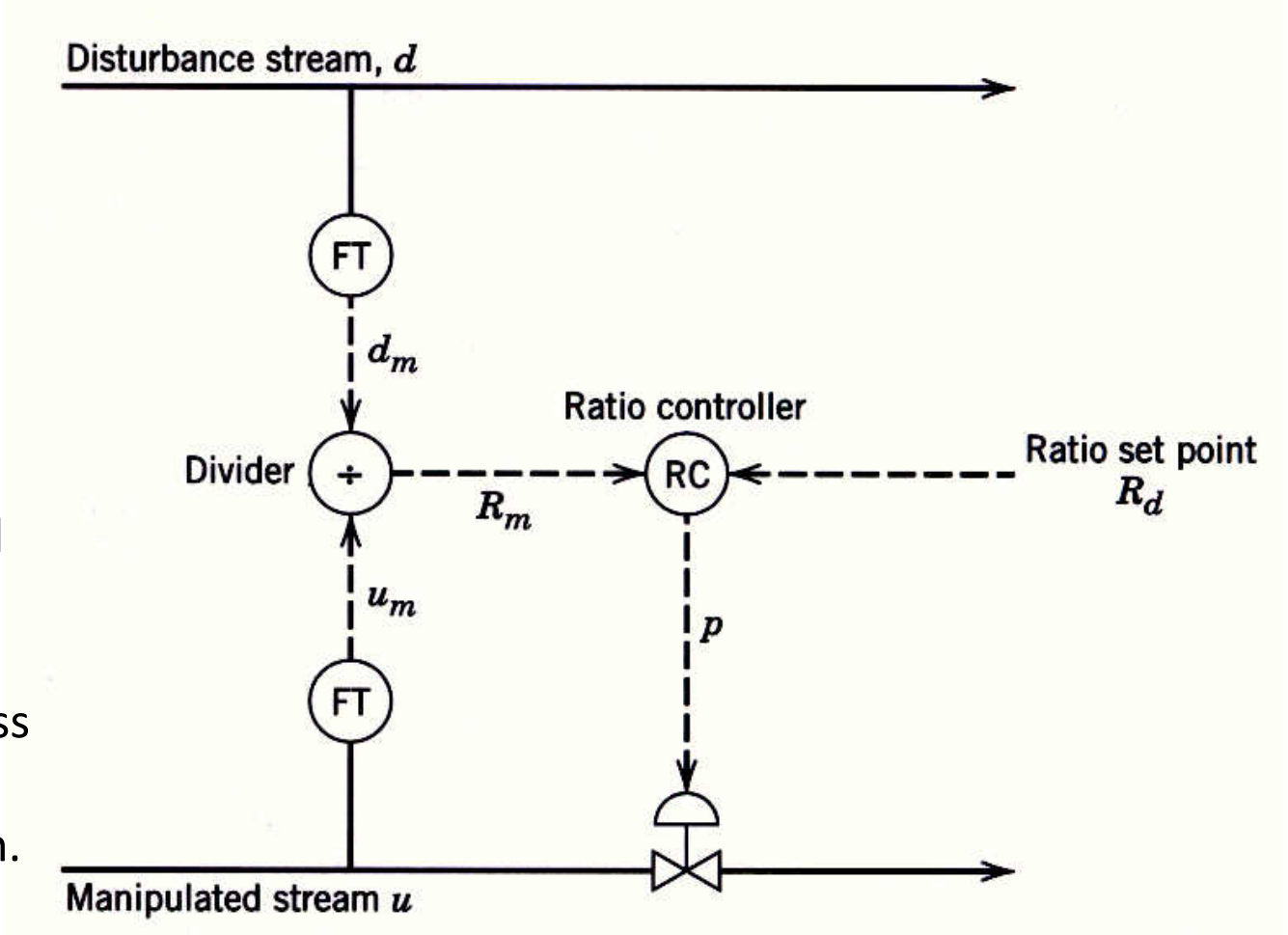
1. Setting the relative amounts of components in blending operations

Advantage

Actual ratio *R* is calculated.

Disadvantage

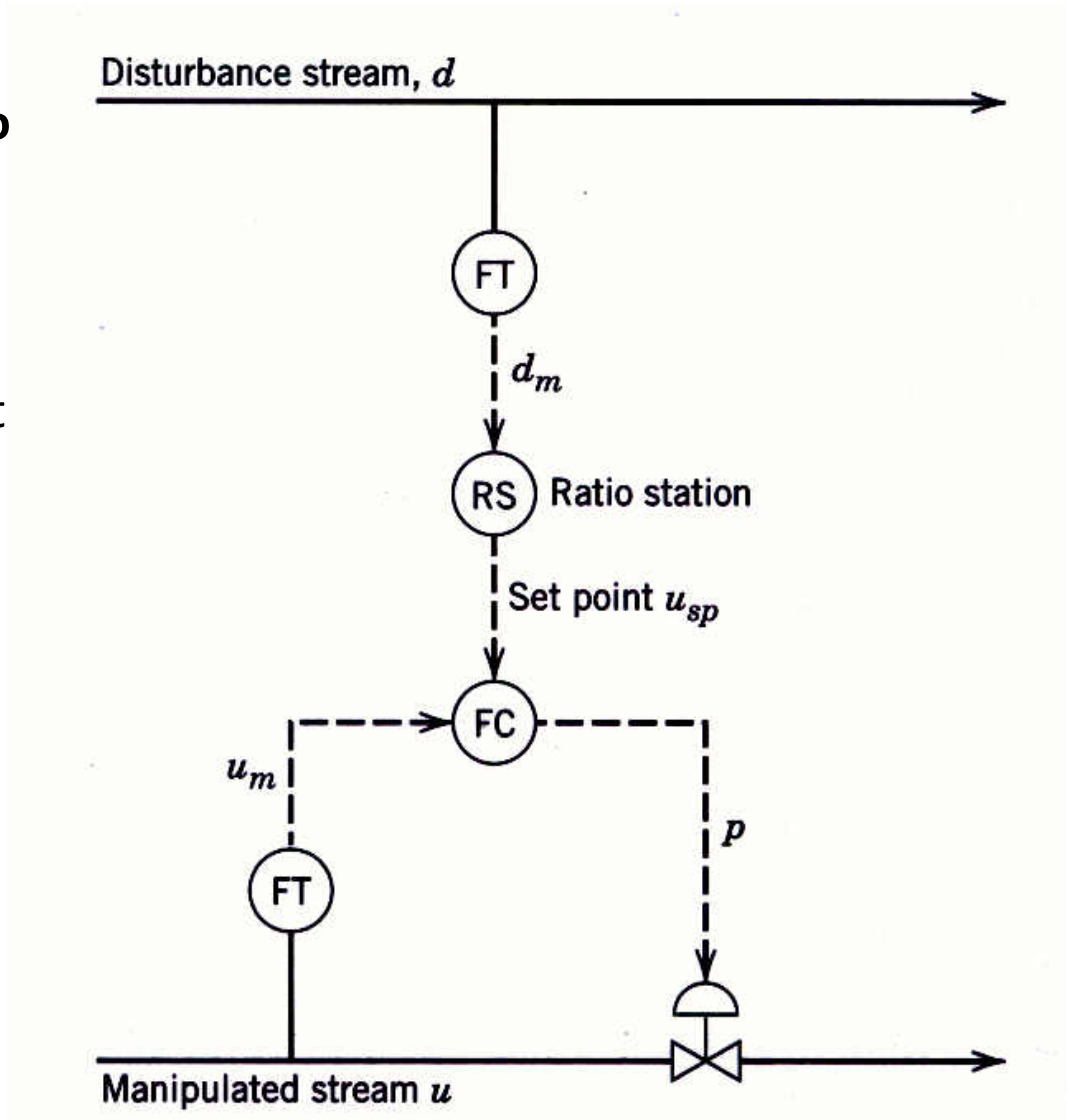
Divider element must be included in the loop, and this element makes the process gain vary in a nonlinear fashion.



Typical applications of ratio control

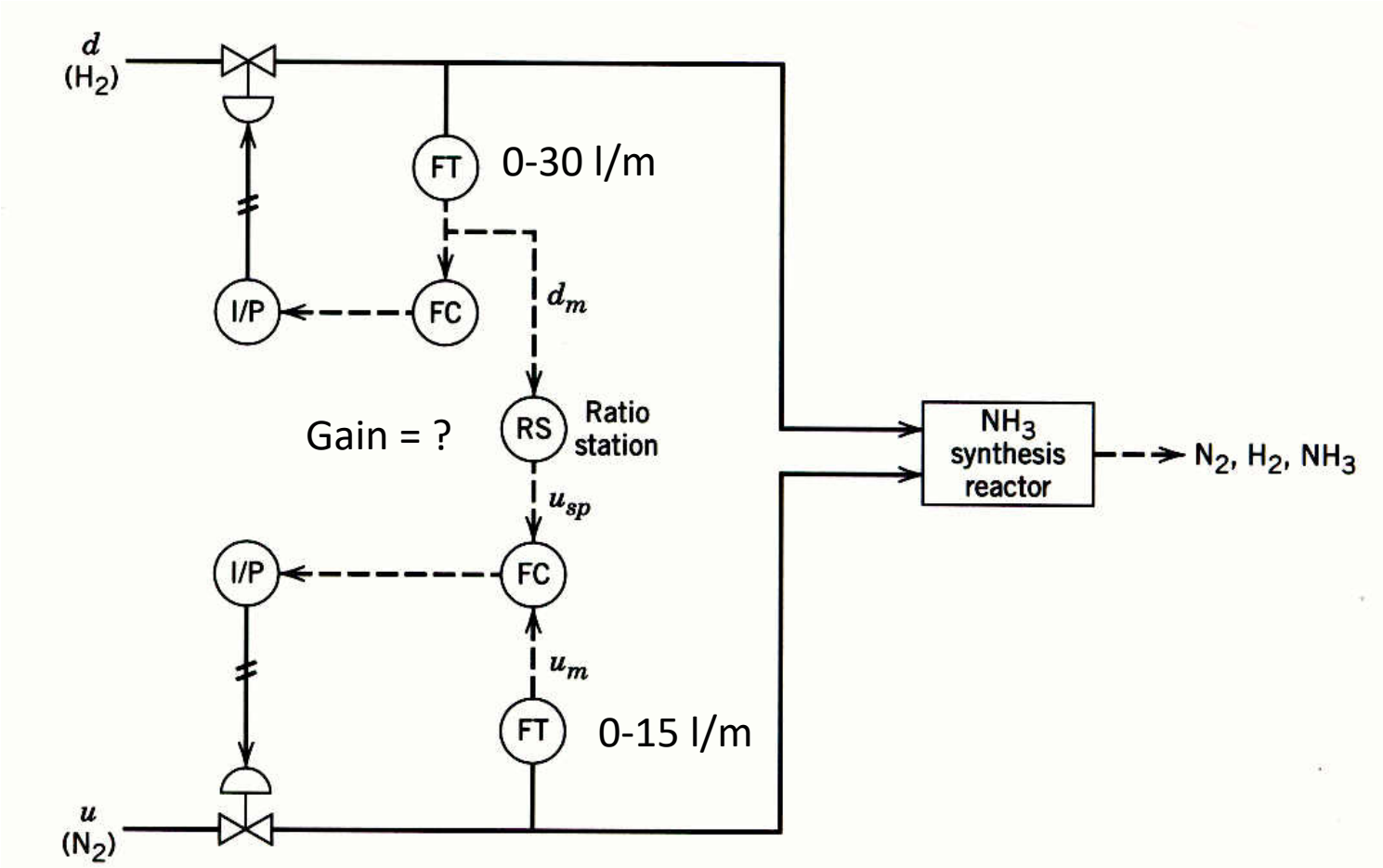
Preferred Scheme of Ratio Control.

- Regardless of how ratio control is implemented, the process variables must be scaled appropriately.
- Gain setting for the ratio station K_r must take into account the spans of the two flow transmitters.
- $K_r = R_d \frac{S_d}{S_u}$

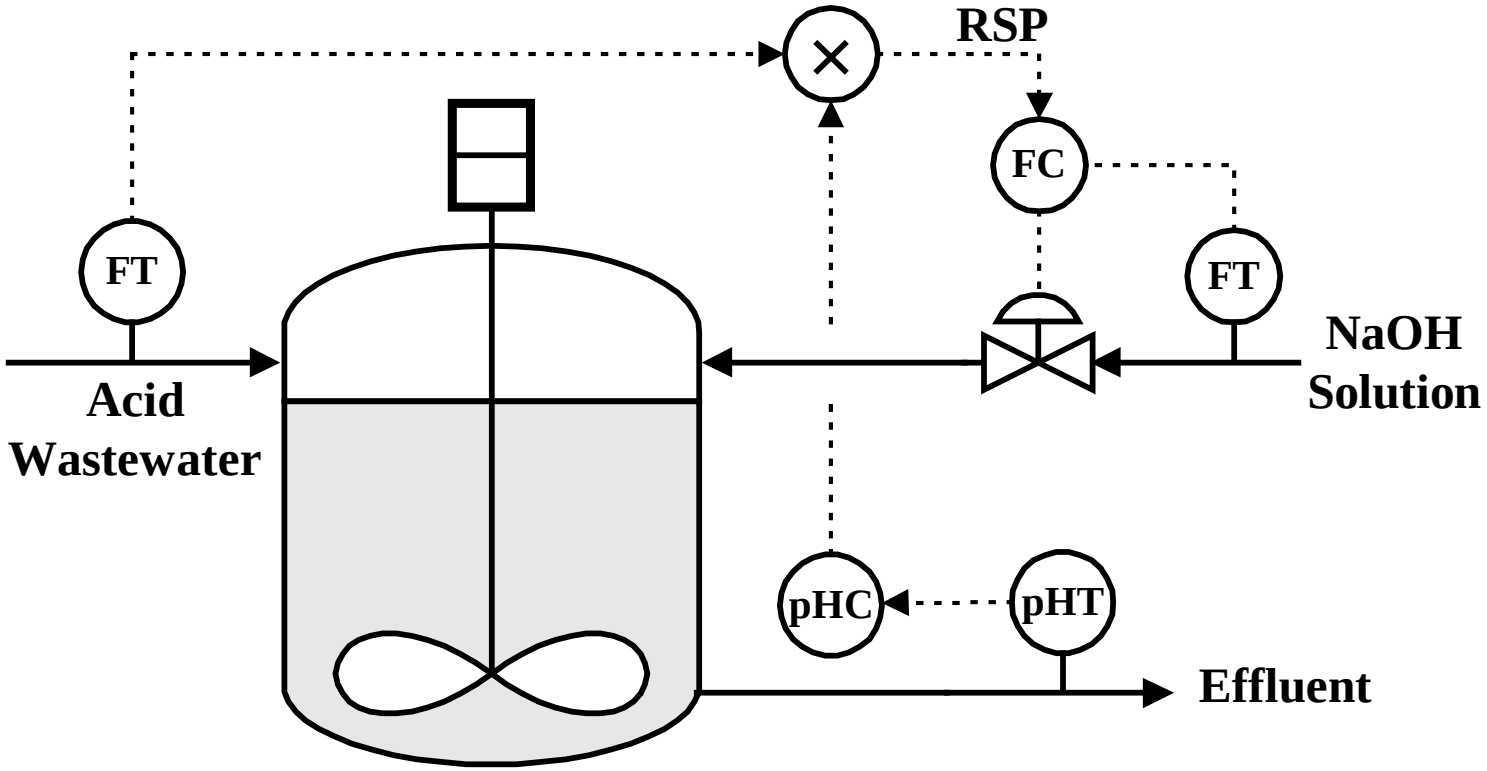


Typical applications of ratio control

- Maintaining a stoichiometric ratio of reactants to a reactor

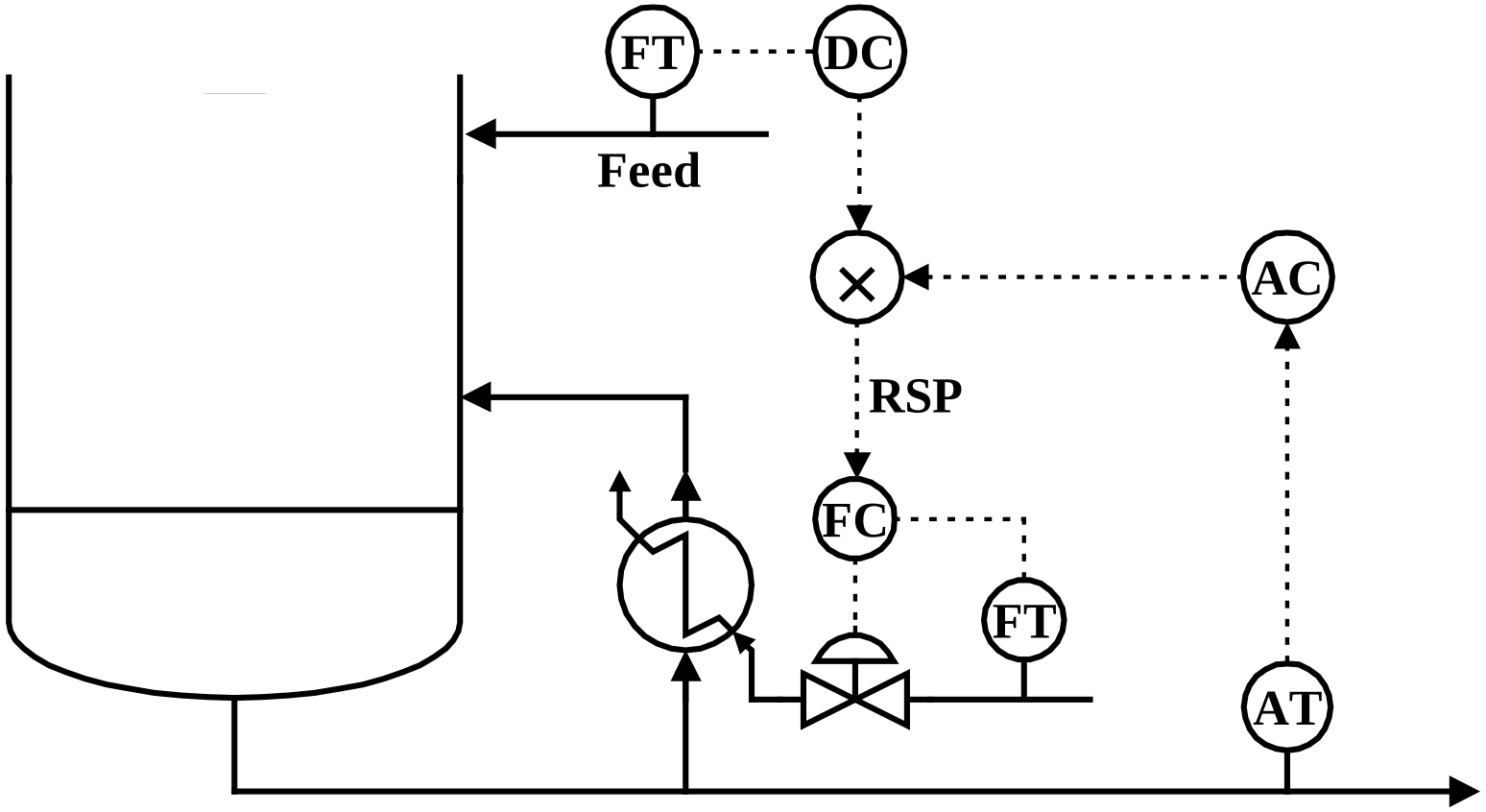


Ratio Control for Wastewater Neutralization



The output of the pH controller is the ratio of NaOH flow rate to acid wastewater flow rate; therefore, the product of the controller output and the measured acid wastewater flow rate become the setpoint for the flow controller of the NaOH addition.

Ratio Control Requiring Dynamic Compensation



Override/Select Controls

- Process are many times operated at the safety or equipment limits in order to maximize process throughput.
- During upset periods, it is essential that safety limits are enforced.

Objective:

- Regulate level and exit flow rate of sand water slurry
- Slurry velocity in the exit line must be above lower limit

Normal : LC is operating

Too Low Flow: FC overtakes

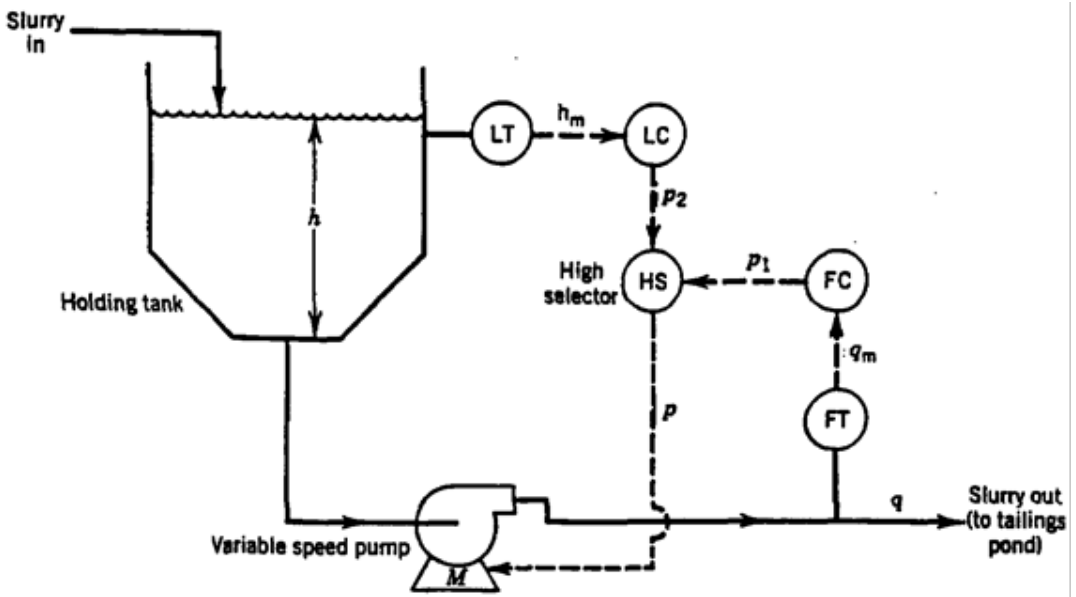
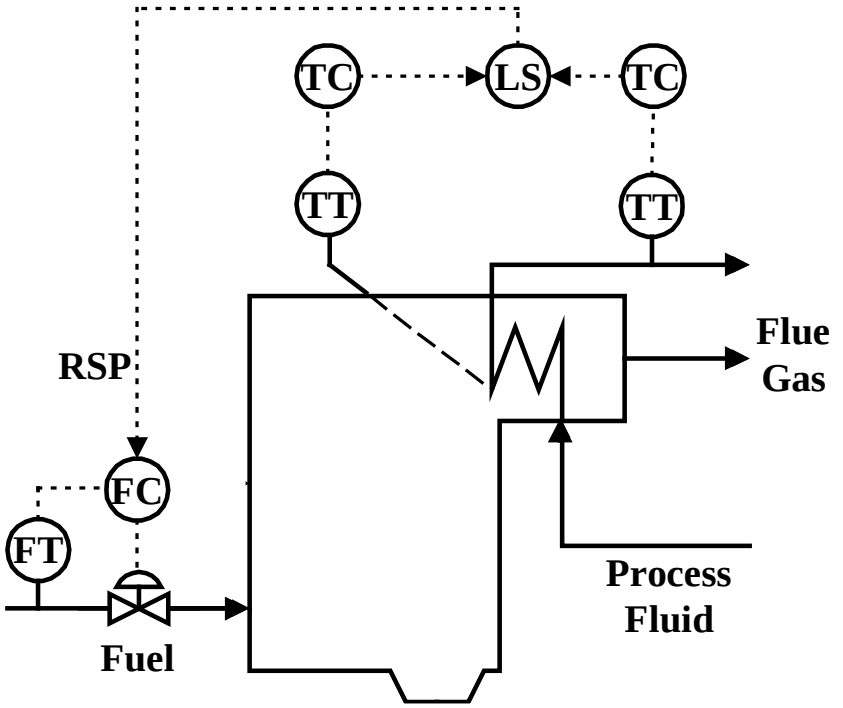


Figure 18.14. A selective control system to handle a sand/water slurry.

Furnace Tube Temperature Constraint Control

- Under normal operation, the controller adjusts the furnace firing rate to maintain process stream at the setpoint temperature.
- At higher fuel rates, excessive tube temperatures can result greatly reducing the useful life of the furnace tubes.
- The LS controller reduces the firing rate to ensure that the furnace tubes are not damaged.



Column Flooding Constraint Control

Objectives:

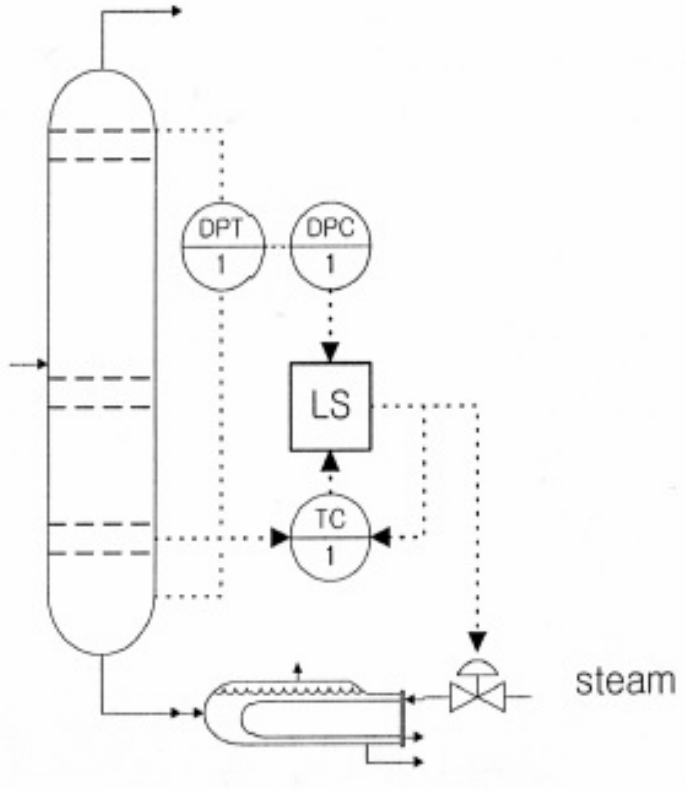
- Maintain the temperature at set point (composition control)
- Maintain $\Delta P < \Delta P_{max}$ (preventing flooding)

Normal: temperature controller is working

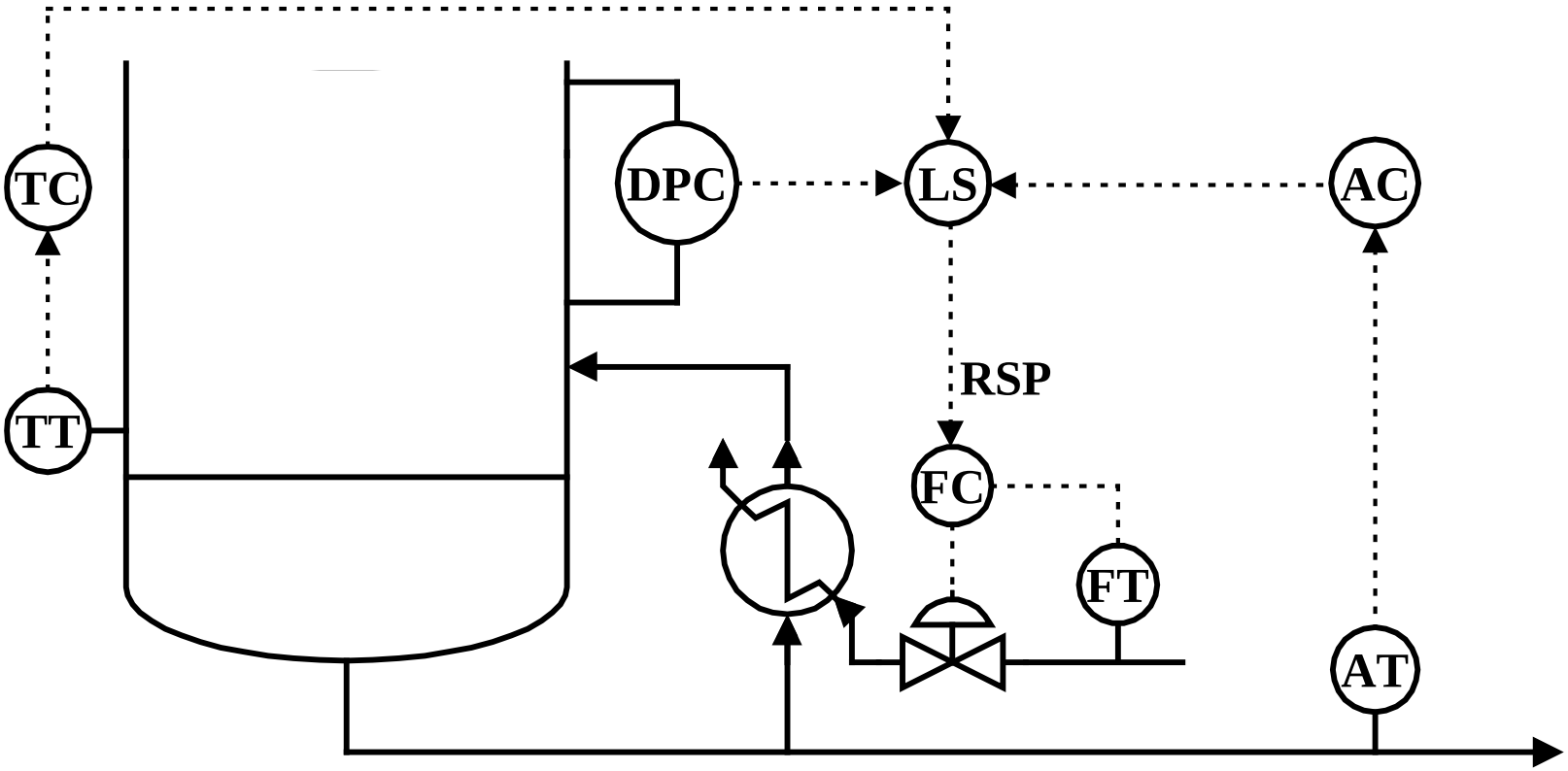
If ΔP is too high, the differential pressure (DP) controller takes over and reduce the steam flow set point.

Temp. controller: PI controller

DP controller: tightly tuned
P control with flooding limit of DP

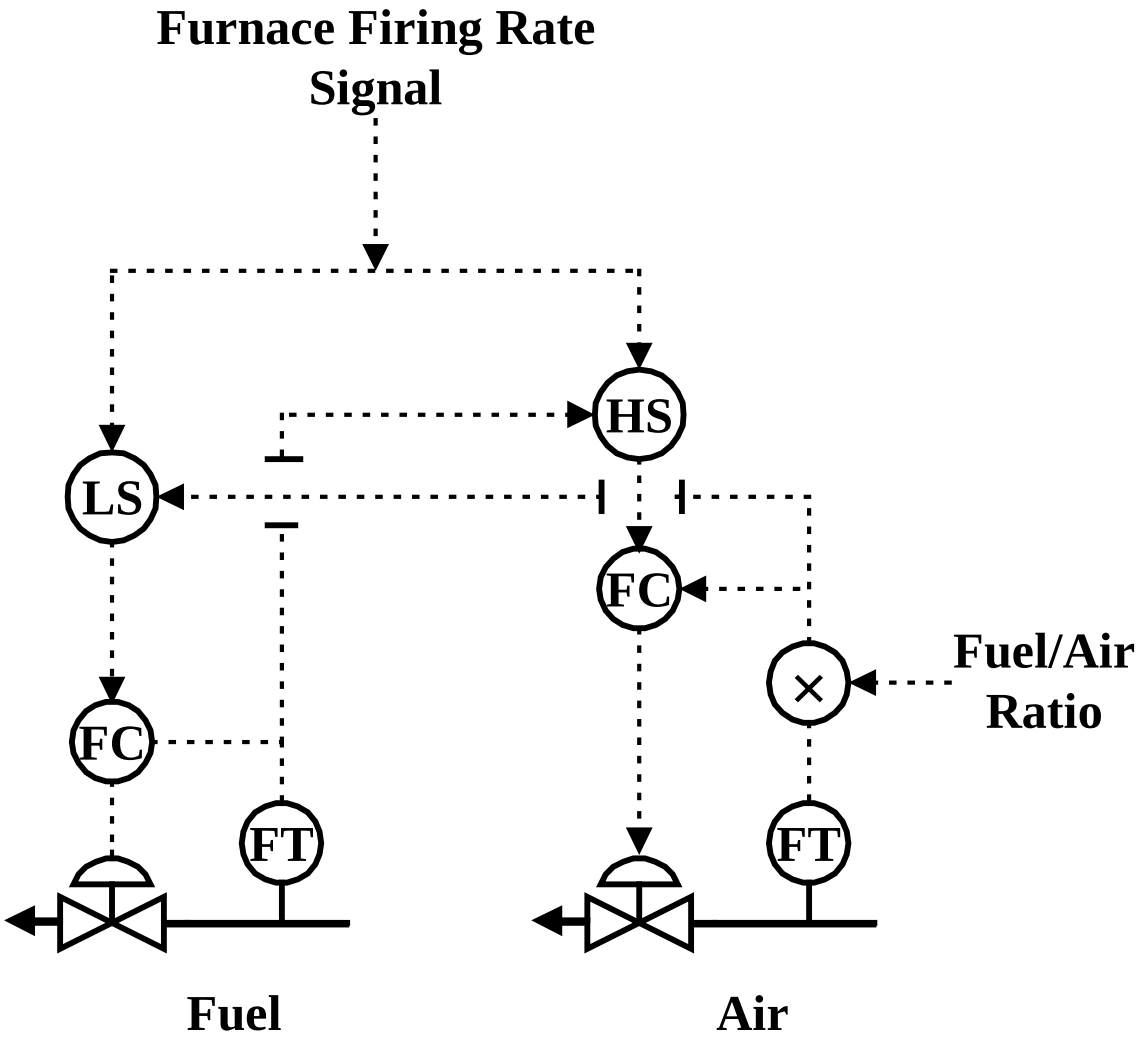


Controlling Multiple Constraints



Cross-Limiting Firing Controls

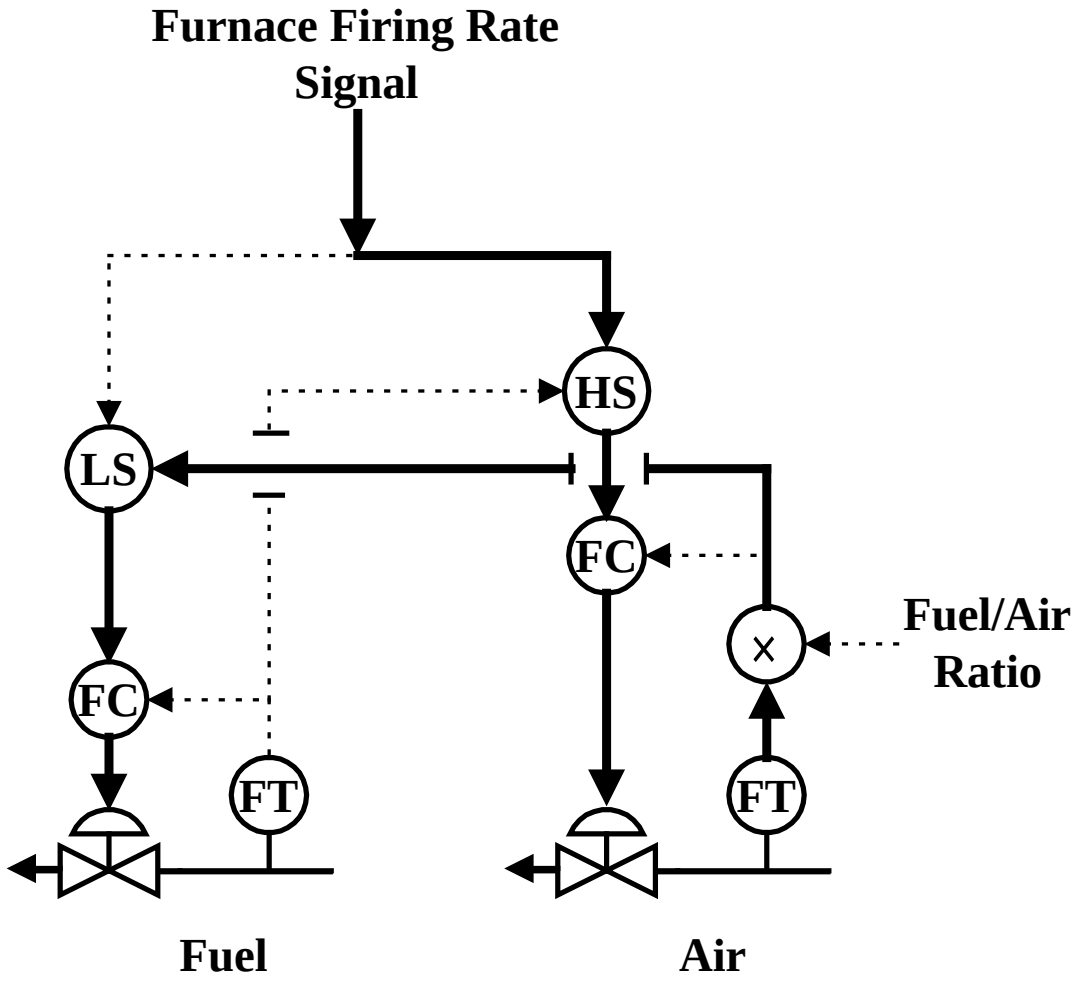
It is critical that excess oxygen is maintained during firing rate increases or decreases or CO will form.



Cross-Limiting Firing Controls

It is critical that excess oxygen is maintained during firing rate increases or decreases or CO will form.

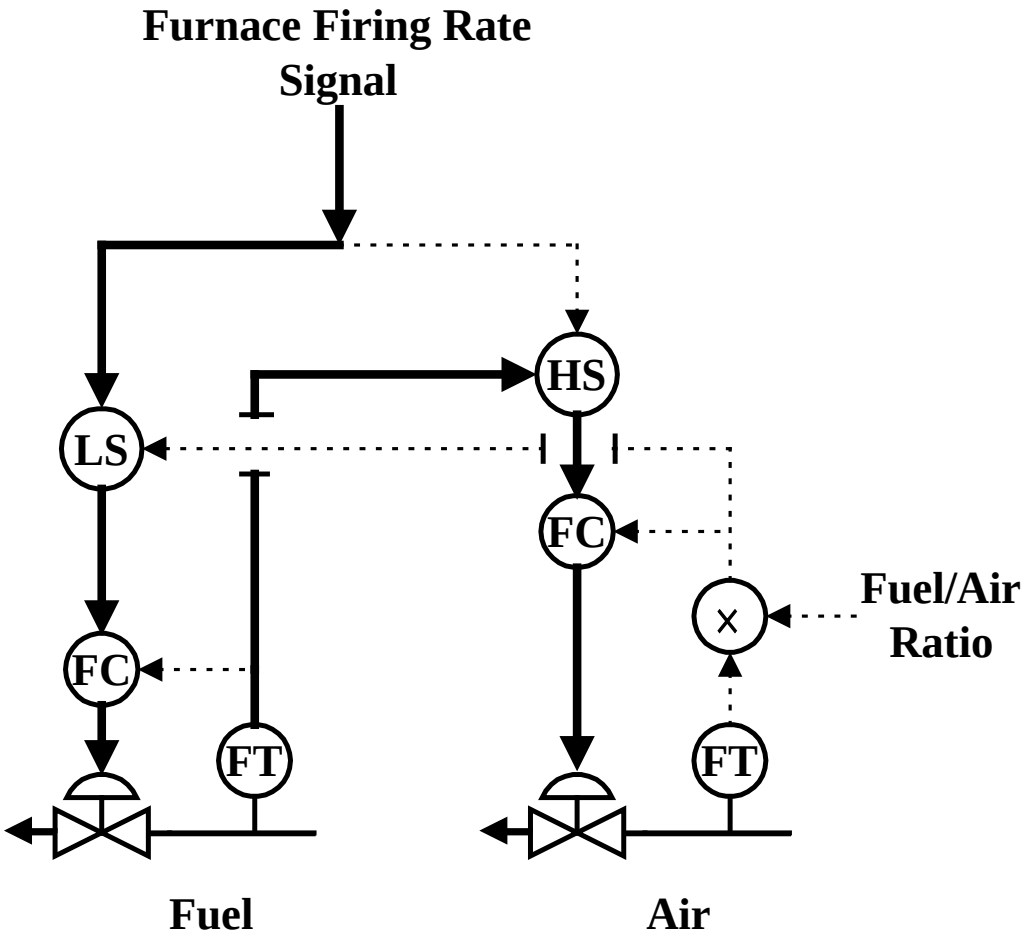
When the firing rate is increased, the air flow rate will lead the fuel flow rate.



Cross-Limiting Firing Controls

It is critical that excess oxygen is maintained during firing rate increases or decreases or CO will form.

When the firing rate is decreased, the fuel flow rate will lead the air flow rate.



Valve Position Control

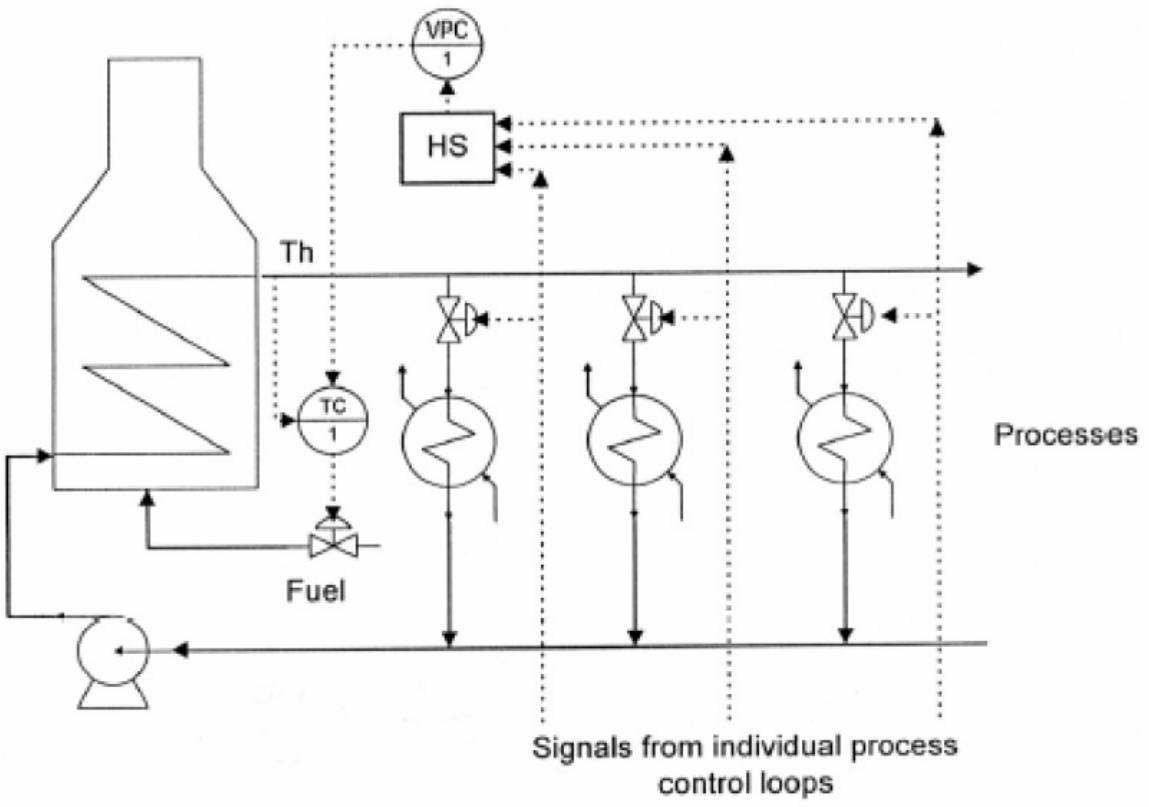
Objectives:

- Supply energy to downstream processes as they require
- Minimize the energy consumption of heater

Heater outlet controller: maintain the temp of the heater as it directed for enough supply of energy to down stream processes

Valve position controller:

- Adjust the TC set point so that the valve opening of at least one of the valves is near “fully open”. (slow control)
- I-control can be used. (slow but no offset)
- The SP should be around 90-95% (fully open).

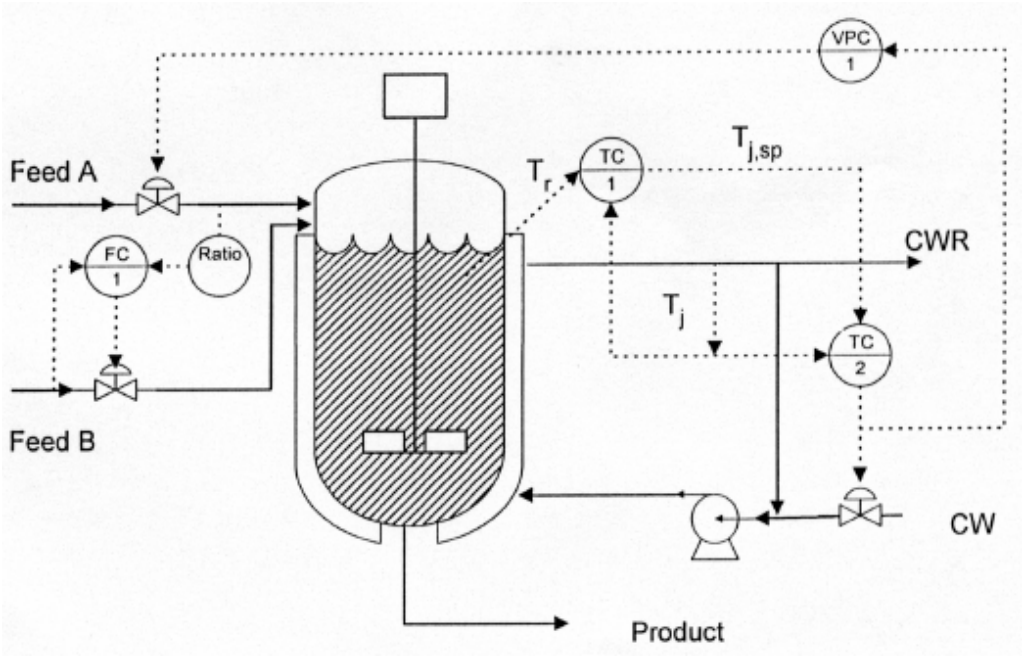


Mixing Tank Cooling Control

Objectives:

- Remove the heat of mixing and maintain mixture temperature
- Maximize the production of mixed feed

Cascaded jacketed tank temp controller: maintain the temp of the mixture by removal of heat of mixing using cooling water



Valve position controller:

- Increase the feed flow of A while cooling capacity allows. (slow control)
- Mix ratio is maintained by ratio control scheme
- The SP should be around 90-95% (fully open).

Floating pressure of distillation column

Objectives:

- Maintain the column pressure by adjusting reflux flow rate
- If the level is too low (below the heat transfer area), the vent must be open to relieve the column pressure.

Pressure Controller: control the P by adjusting reflux flow rate.

Level controller: takes over if level is too low. ($L<L$min)

- If LC takes over, there is a discrepancy, and it opens the vent valve.
- The K in summing station decides the vent opening.