UCH1603 Process Dynamics and Control

Control of Distillation Columns

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Introduction

Distillation columns have to be carefully operated in order to achieve the required production rates and product quality. The three main objectives of column control can be stated as:

1. To set stable conditions for column operation.
2. To regulate conditions in the column so that the product(s) always meet the required specifications.
3. To achieve the above objective most efficiently, e.g.: by maximising product yield, minimising energy consumption, etc.

Introduction (contd..)

Process variables like temperatures, pressures, flow rates, levels and compositions must be monitored and controlled in any distillation process. These process variables within a distillation system affect one another, whereby a change in one process variable will result in changes in other process variables. Thus, in column control one should be looking at the whole column and not focusing on any particular section only.

Some General Guidelines

- Column pressure — normally controlled at a constant value.
- Feed flow rate — often set by the level controller on a preceding column.
  Feed flow rate is independently controlled if fed from storage tank or surge tank.
- Feed temperature — controlled by a feed preheater. Prior to preheater, feed may be heated by bottom product via feed/bottom exchanger.
- Top temperature — usually controlled by varying the reflux.
- Bottom temperature — controlled by varying the steam to reboiler.
- The compositions — controlled by regulating the reflux flow and boiled-up (reboiler vapour).

Pressure of Distillation Column

Pressure is often considered the prime distillation control variable, as it affects temperature, condensation, vaporisation, compositions, volatilities and almost any process that takes place inside the column.
Column pressure control is frequently integrated with the condenser control system.

Condenser and Pressure Control

The 3 main methods of pressure and condensation control are:

1. vapor flow variation,
2. flooded condenser, and
3. cooling medium flow variation.

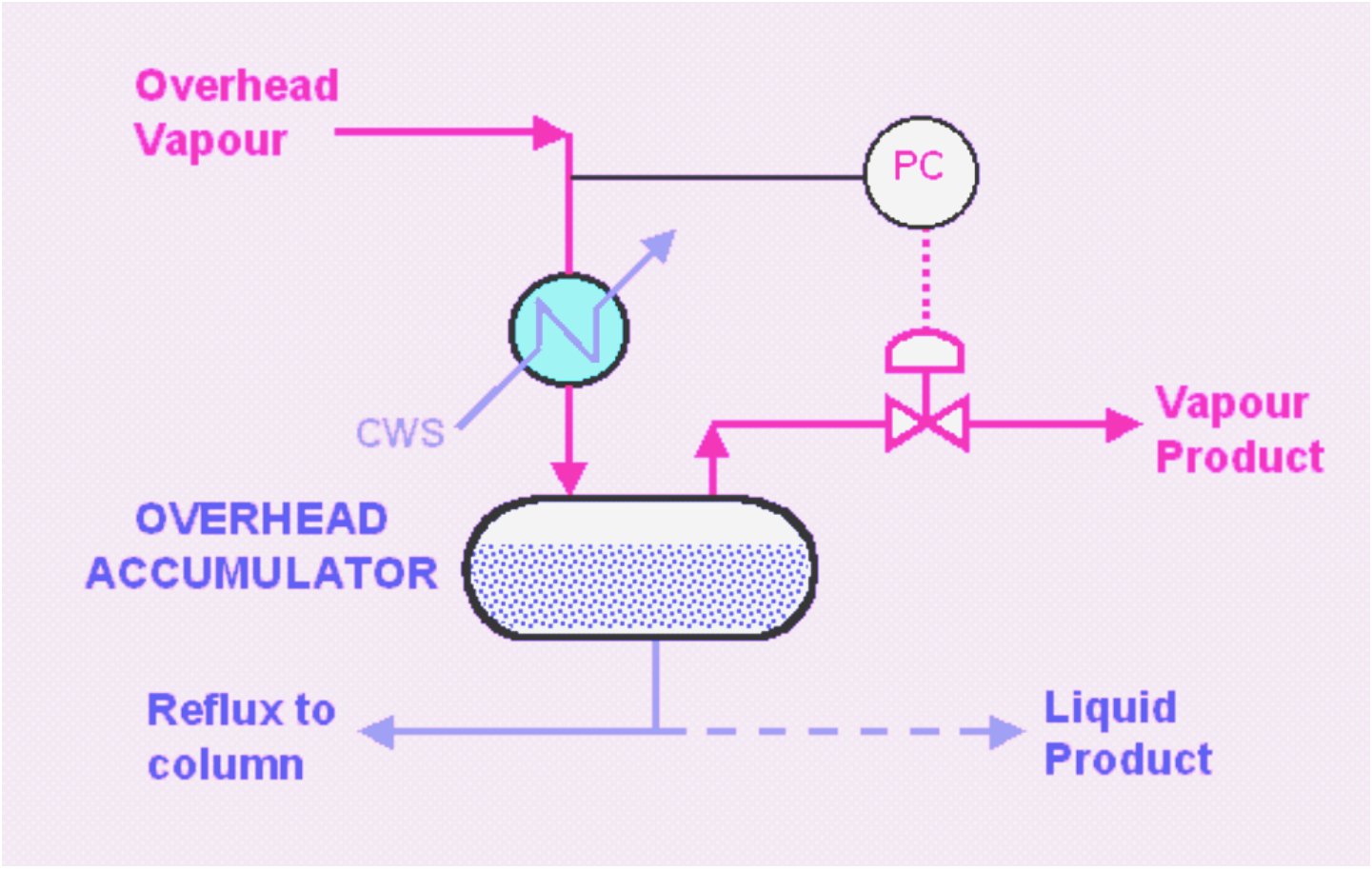
Condenser and Pressure Control (contd..)

Vapor Flow Variation

The simplest and direct method for column producing a vapor product. The pressure controller regulates the vapor inventory and therefore the column pressure. An important consideration here is the proper piping of the vapor line to avoid liquid pockets.

Condenser and Pressure Control (contd..)

Vapor Flow Variation



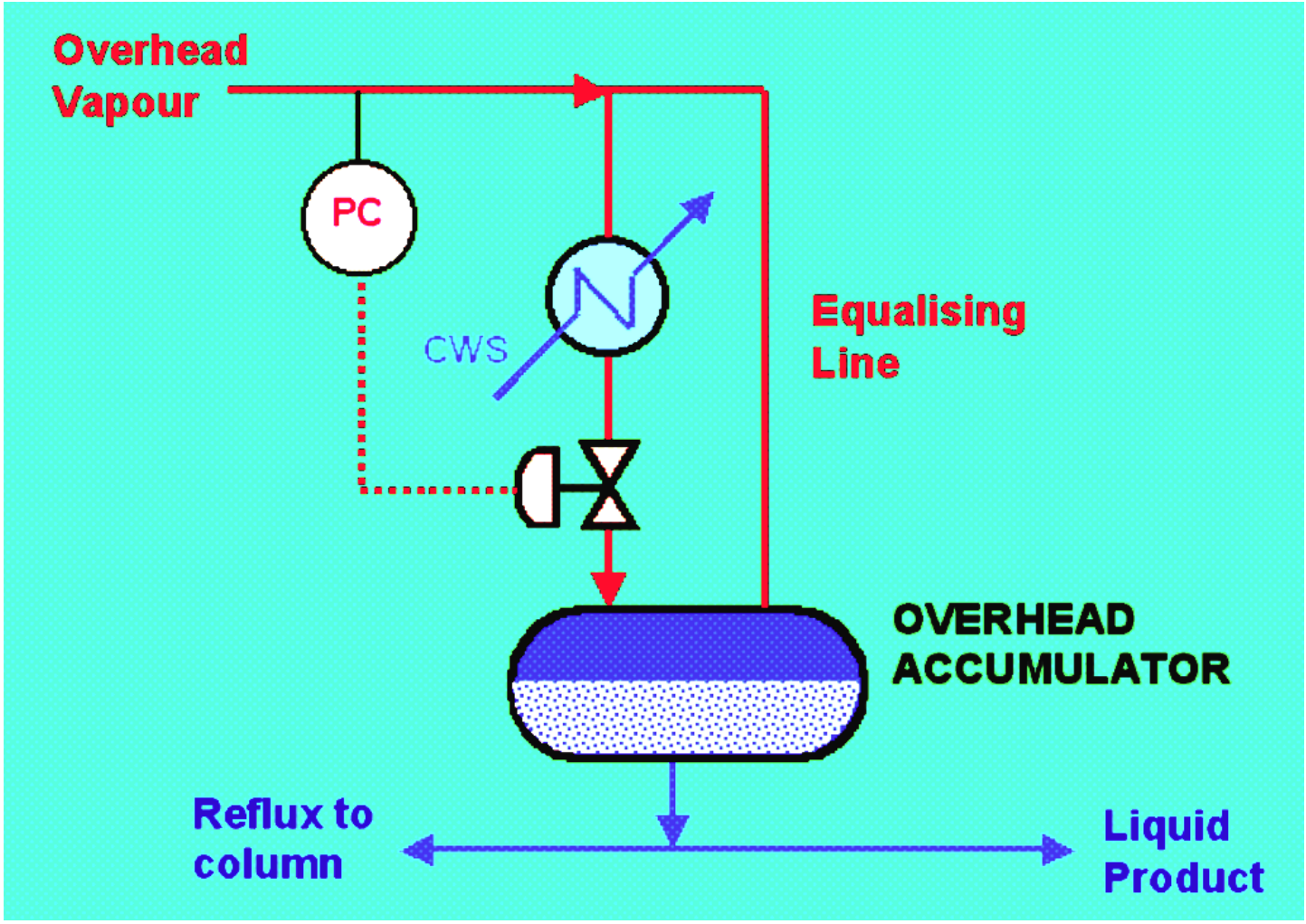
Condenser and Pressure Control (contd..)

Flooded Condenser

This method is used with total condensers generating liquid product. Part of the condenser surface is flooded with liquid at all times. The flow of condensate from the condenser is controlled by varying the flooded area. Increasing the flooded area (by reducing flow) increases the column pressure (less surface area for condensation).

Condenser and Pressure Control (contd..)

Flooded Condenser



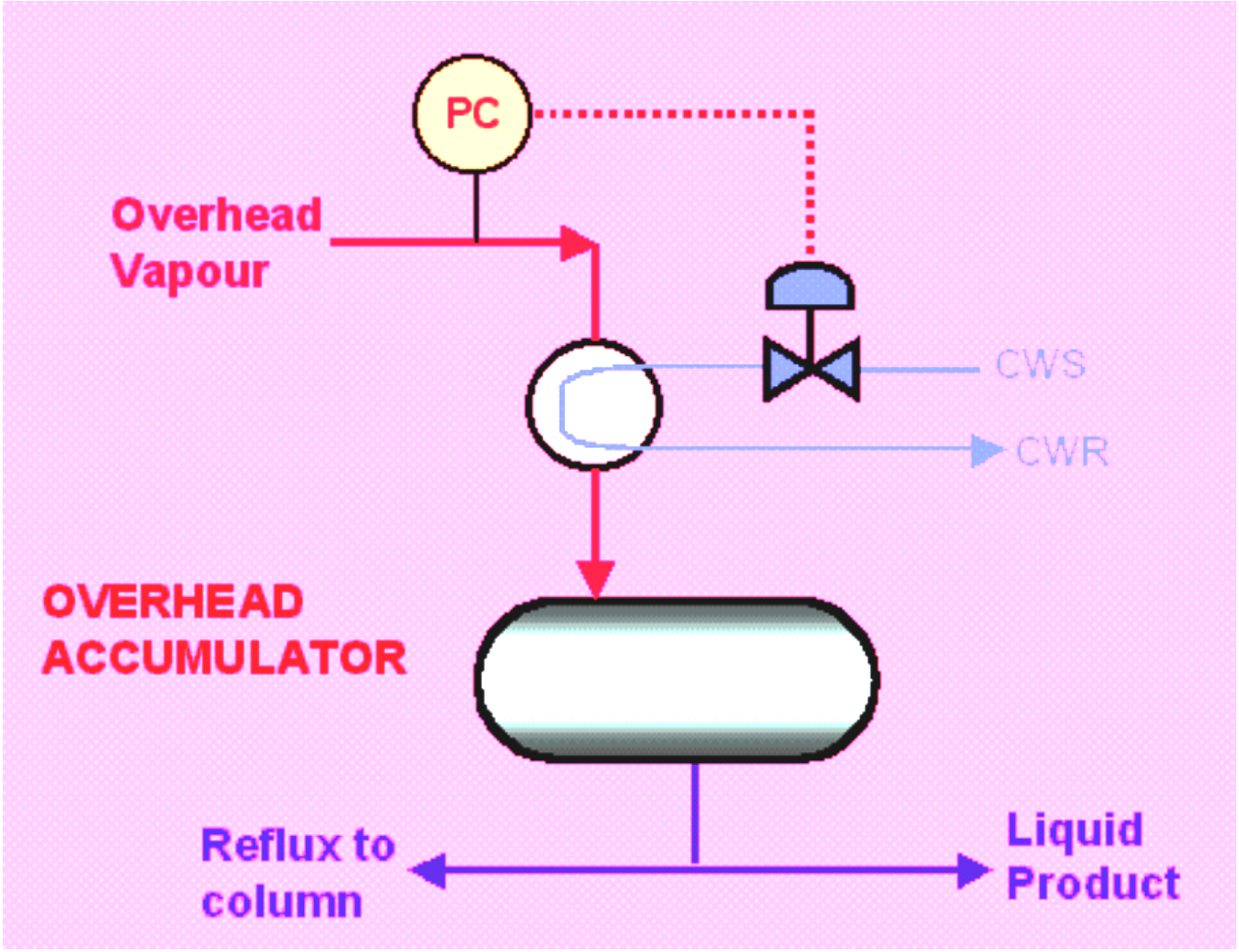
Condenser and Pressure Control (contd..)

Coolant Flow

Pressure can also be controlled by adjusting the flow of coolant to the condenser. Operation using cooling water can cause fouling problems at low flow condition, when cooling water velocity is low and outlet temperature is high.

Condenser and Pressure Control (contd..)

Coolant Flow



Condenser and Pressure Control (contd..)

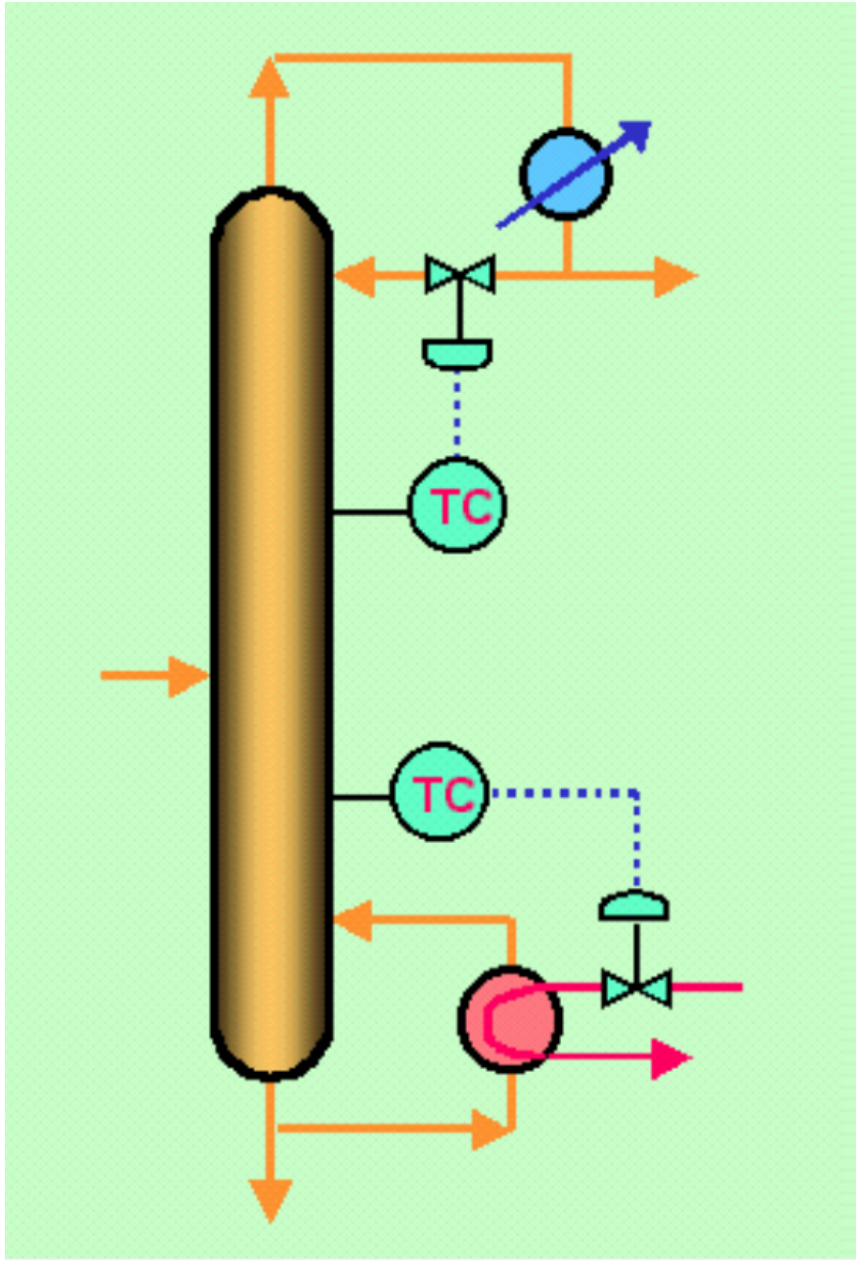
Other Methods

- Pressure control using inerts — when column pressure falls, an inert gas is admitted to raise the column pressure.
- Venting excess gas to flare.

Temperature Control

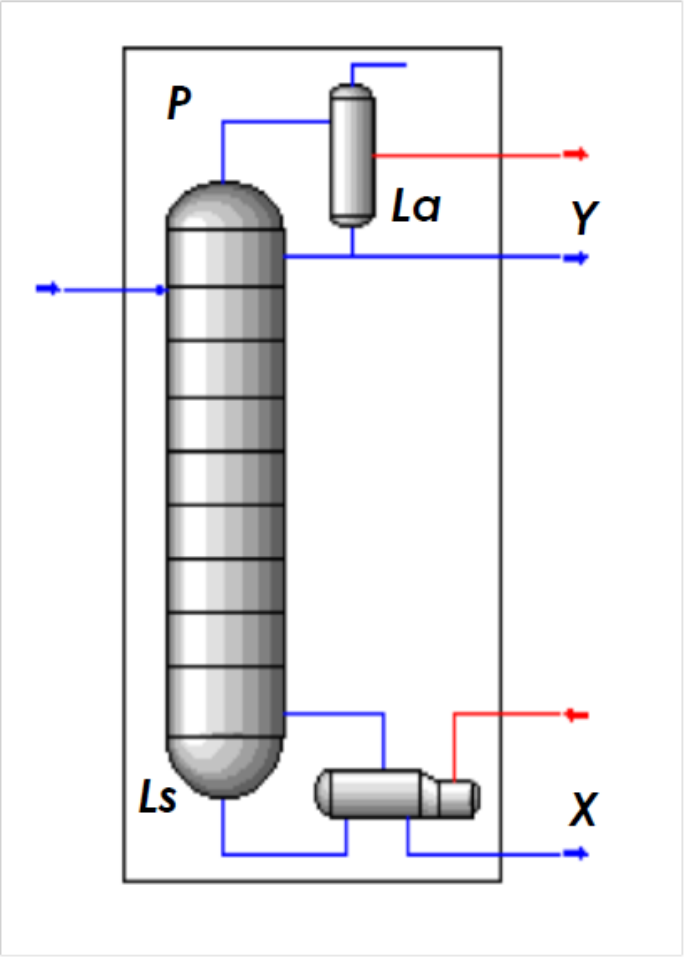
Column temperature control is perhaps the most popular way of controlling product compositions. In this case, the control temperature is used as a substitute to product composition analysis.
Ideally, both top and bottom compositions should be controlled to maintain each within its specifications.

Temperature Control



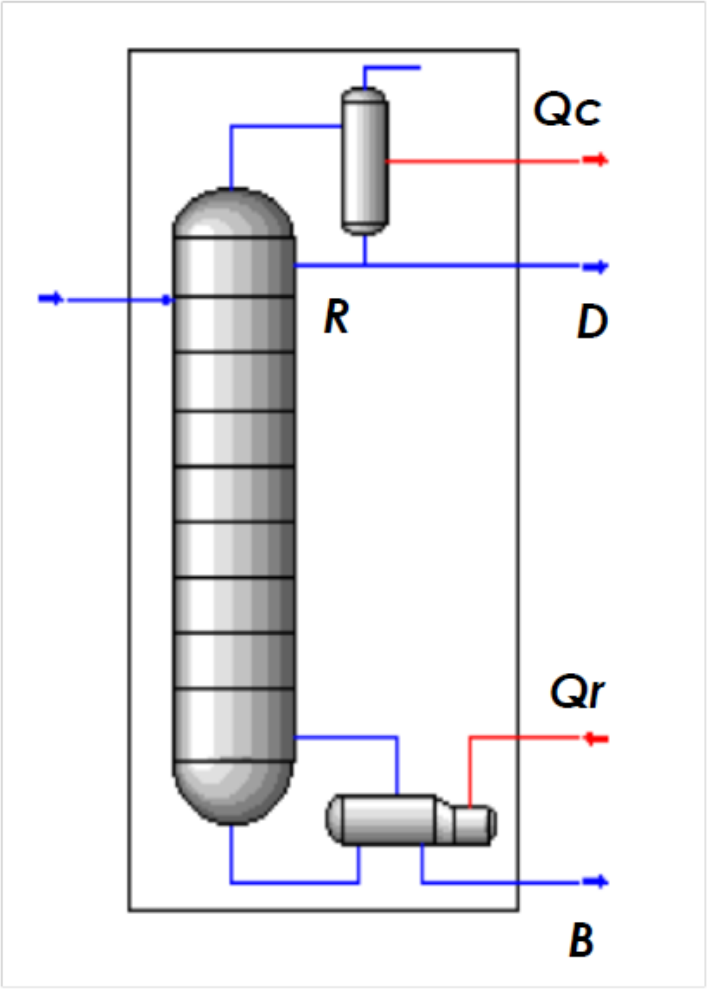
Controlled Variables

distillate composition	*Y*
bottom composition	*X*
accumulator level	*La*
sump level	*Ls*
column pressure	*P*



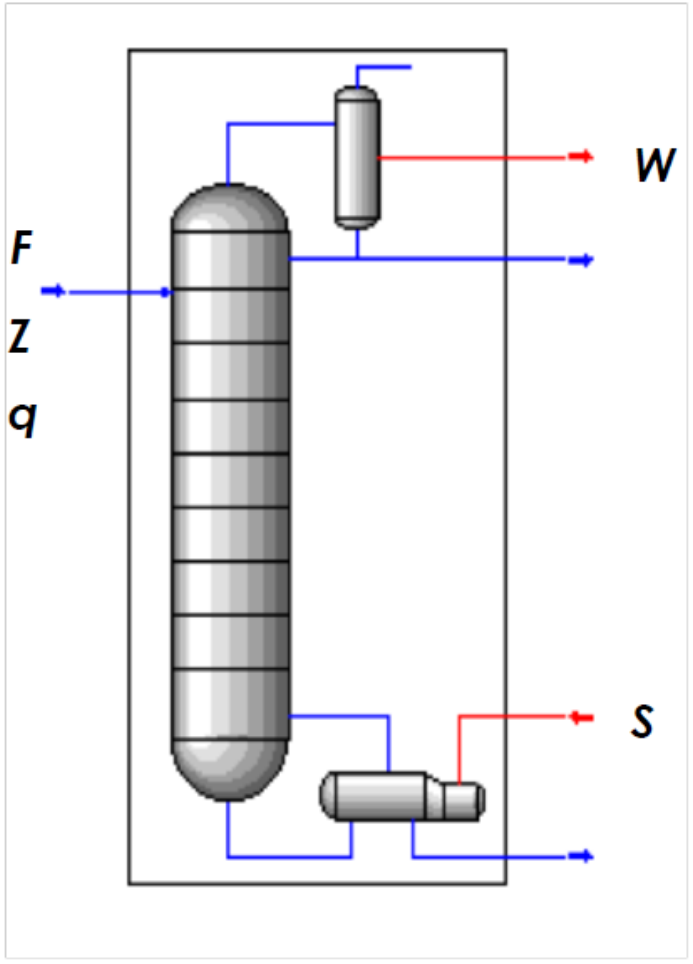
Manipulated Variables

distillate flow	D
bottom flow	B
reflux flow	R
reboiler duty	Qr
condenser duty	Qc

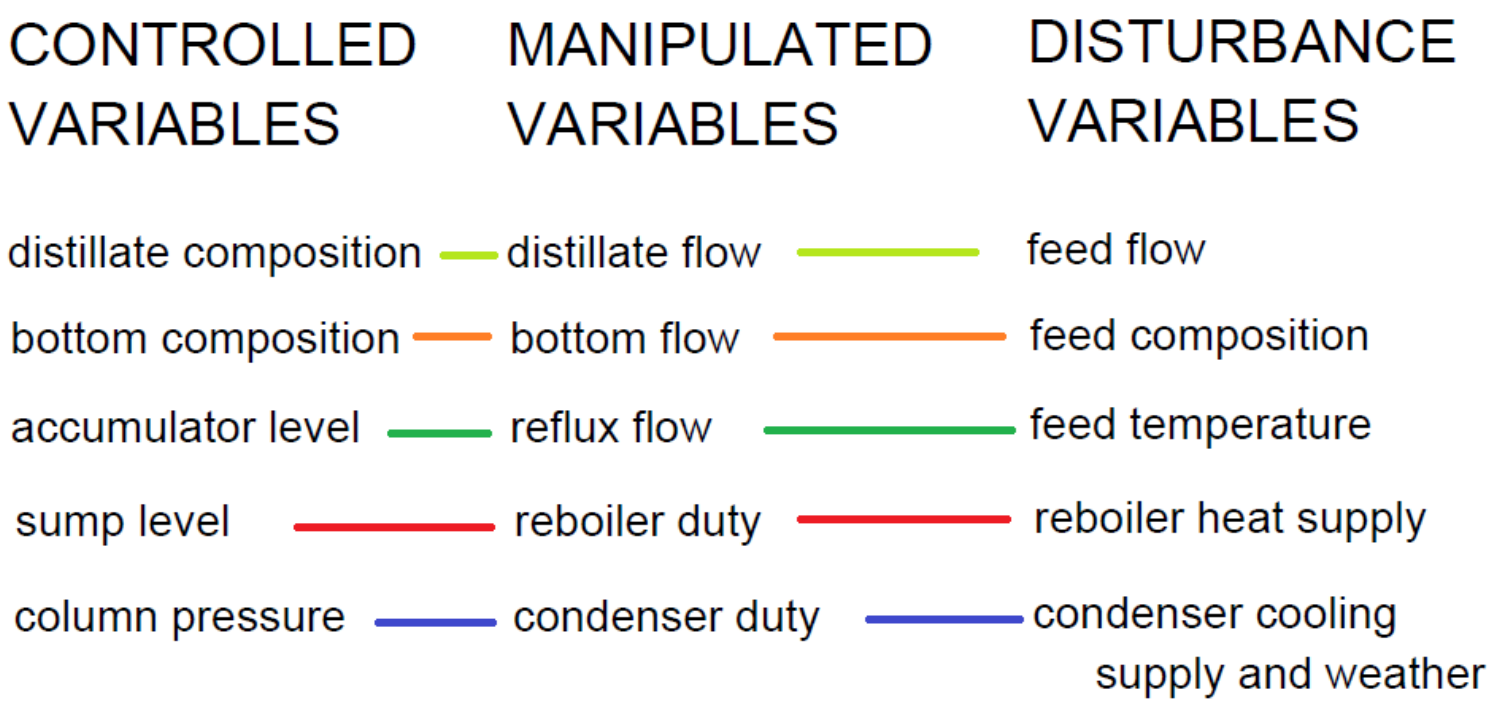


Disturbances

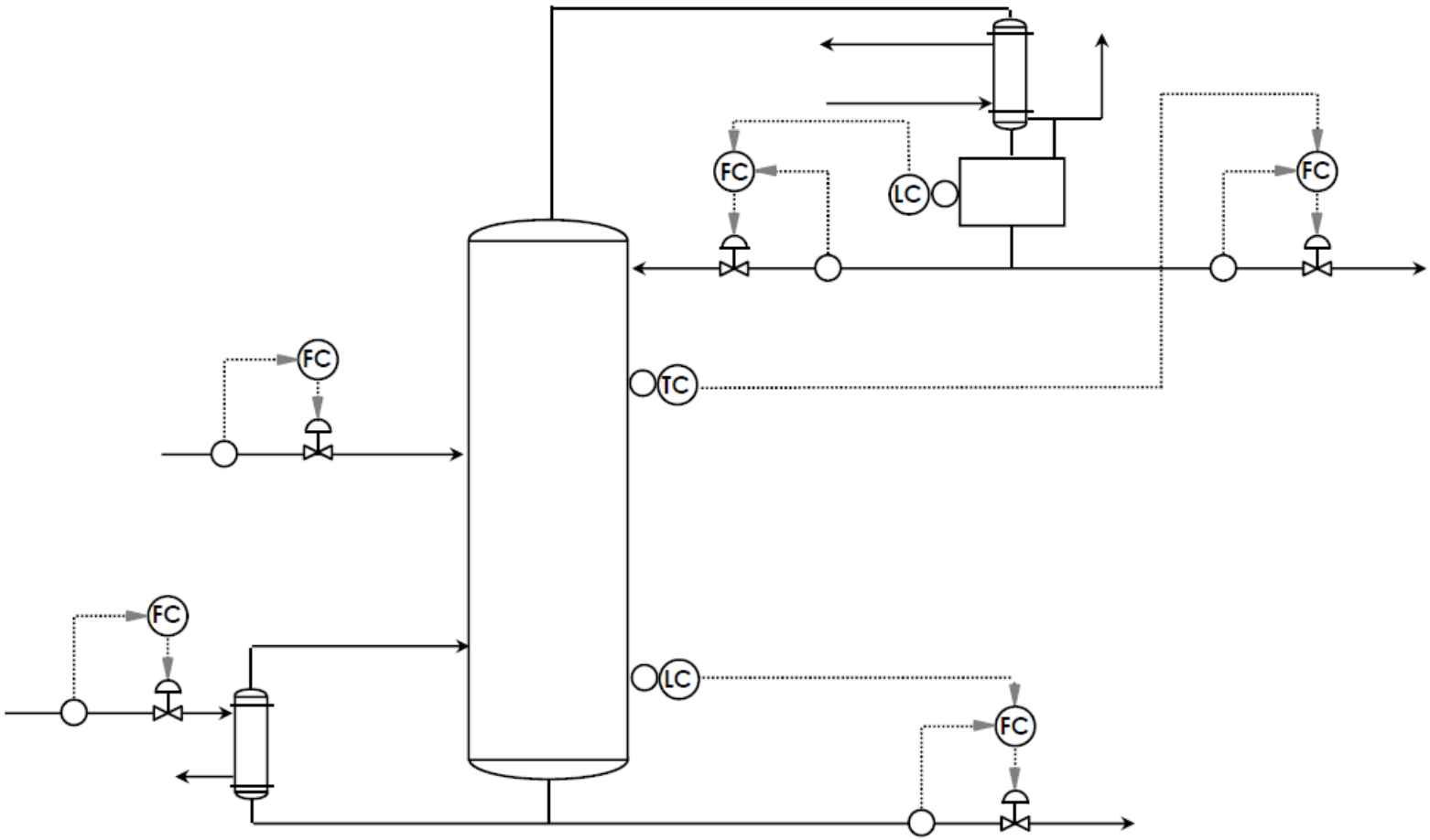
feed flow	F
feed composition	Z
feed temperature	q
reboiler heat supply	S
condenser cooling supply and weather	W



Pairing of Variables



Control Loops



References

- www.separationprocesses.com
- automation.isa.org