Practical Process Control & Dynamic Simulation.
Selected slides from chapters
(39 out of 178 slides)

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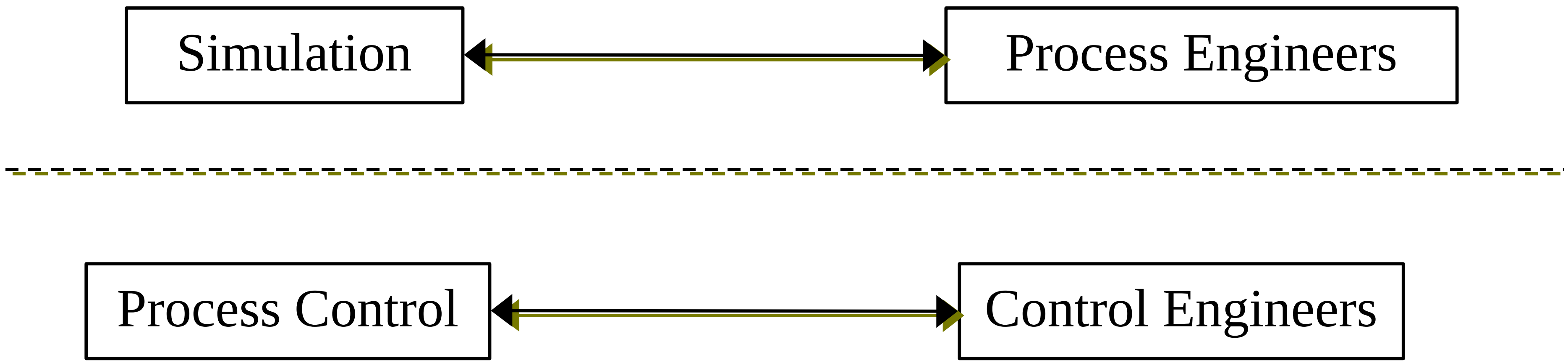
Advanced Control Group (ULL)

Introduction to Simulation and Control

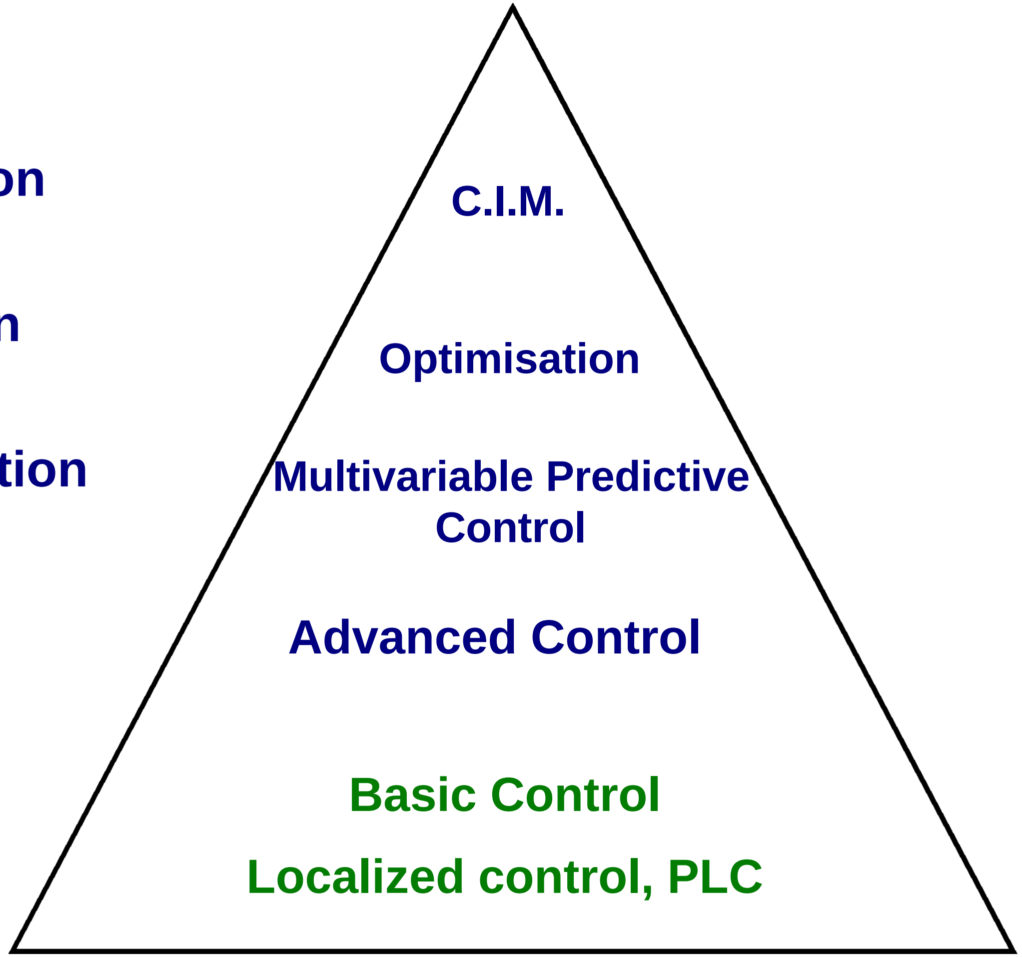
Introduction to Simulation and Control

- Simulation and Process Control are closed activities



New Software helps to cope this difference

LEVEL	OBJECTIVE
4B	Global Optimization
4A	Local Optimization
3B	Quality / Optimization
3A	Stability / Quality
2	Stability / Safety
1	Stability / Safety



Gain, Capacitance and Dead Time

- The three most important process parameters
  - Gain.Change in the controlled variable by means of variation in a manipulated variable, i.e.

$$Kp = \frac{\Delta CV}{\Delta MV}$$

  - Capacity. Resistance of the CV to make effective a change in the MV. Therefore moment of inertia. Relate to Inventories i.e.. Tank level,

$$t\,(time) = \frac{V(volumen)}{F(volumen\,/\,time)}$$

  - Dead Time. Shift the response of a CV from the time where the MV has changed, i.e., Discontinuous Analyzer cycling time,

$$f\,(time)$$

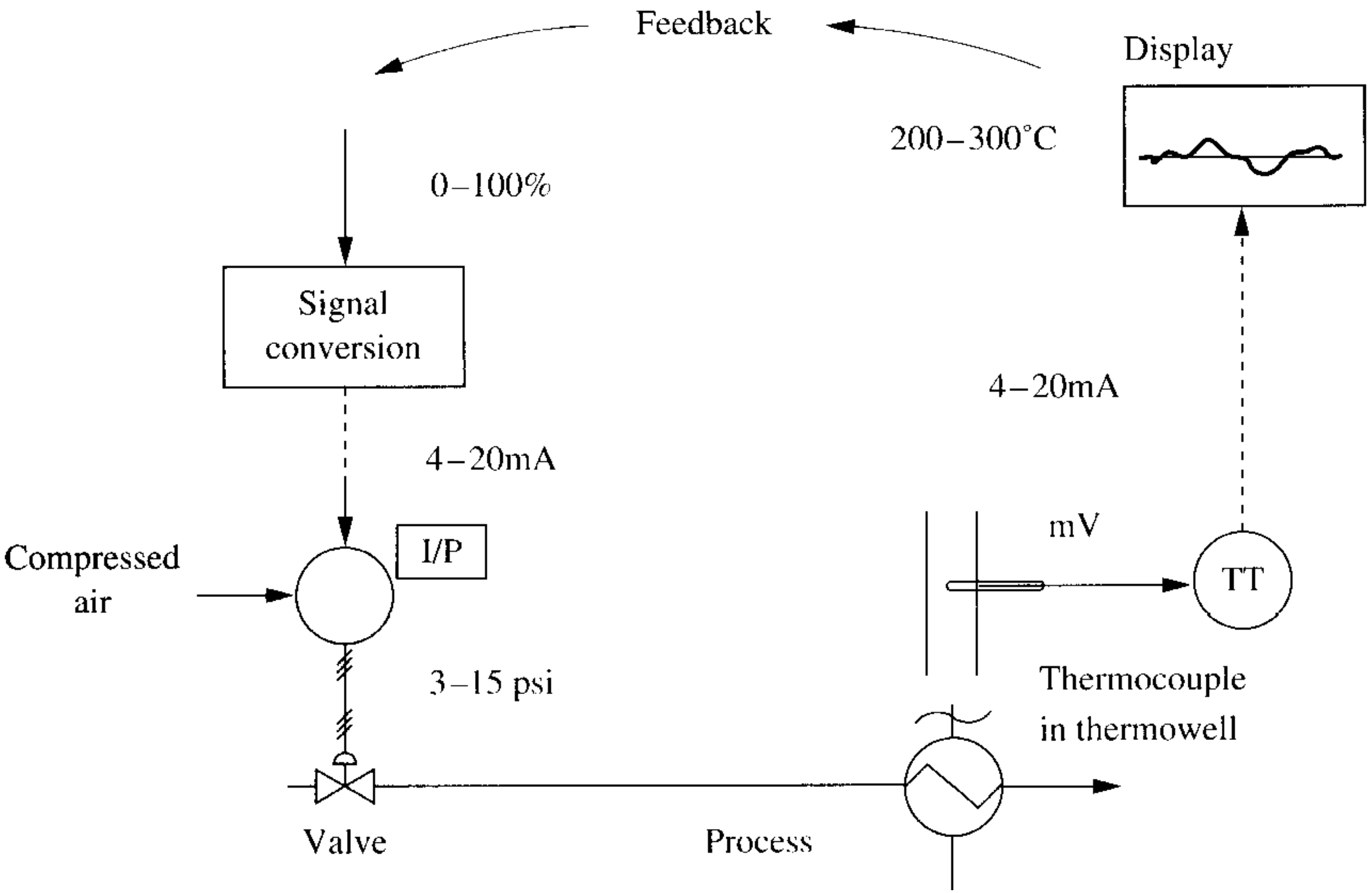
Dynamic Process Characteristics

- **Types**
  - **First Order Systems**
  - **Second Order Systems**
    - Overdamped
    - Critically Damped
    - Underdamped
  - **Dead Time**
  - **Integrator**

- **Self-Regulation**. Tends to steady state after perturbation. The value of the rate of change of the CV **depends** on its value.
- **Non-Self-Regulation**. The value of the rate of change of the CV **does not** depend on its value.

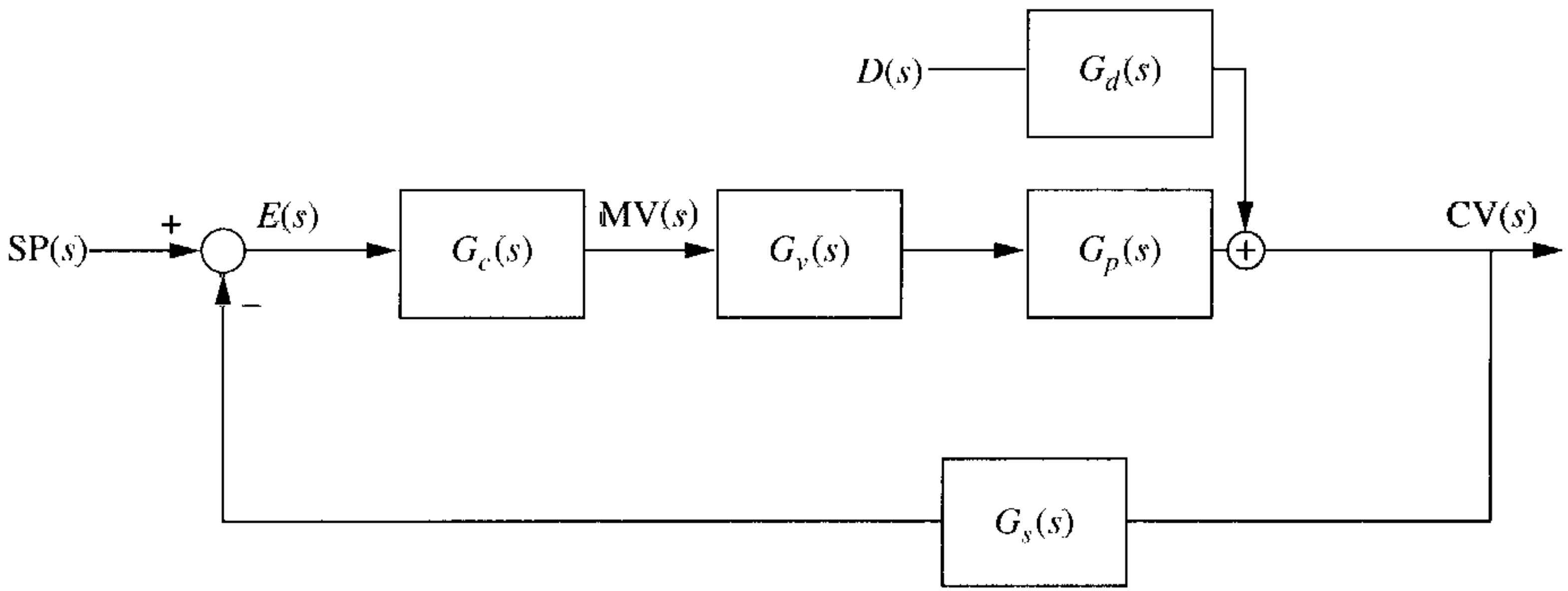
Feedback Control Loops

Process Elements in the Control Loop



Series of Non-Interacting Systems

Feedback Control Loops. Block Diagram

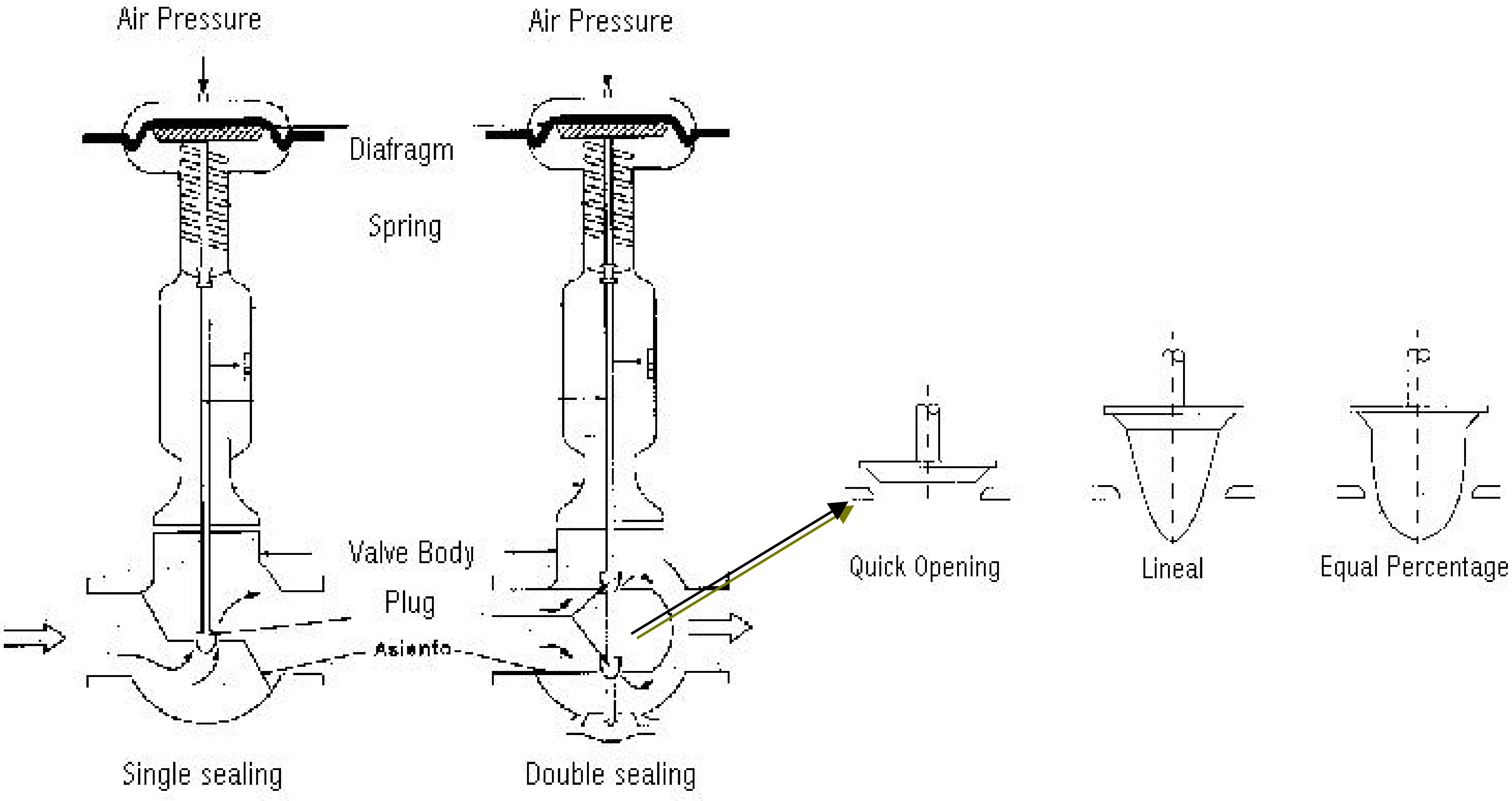


$G_c(s)$ = Controller
$G_v(s)$ = Transmission, transducer, and valve
$G_p(s)$ = Process
$G_s(s)$ = Sensor, transducer, and transmission
$G_d(s)$ = Disturbance

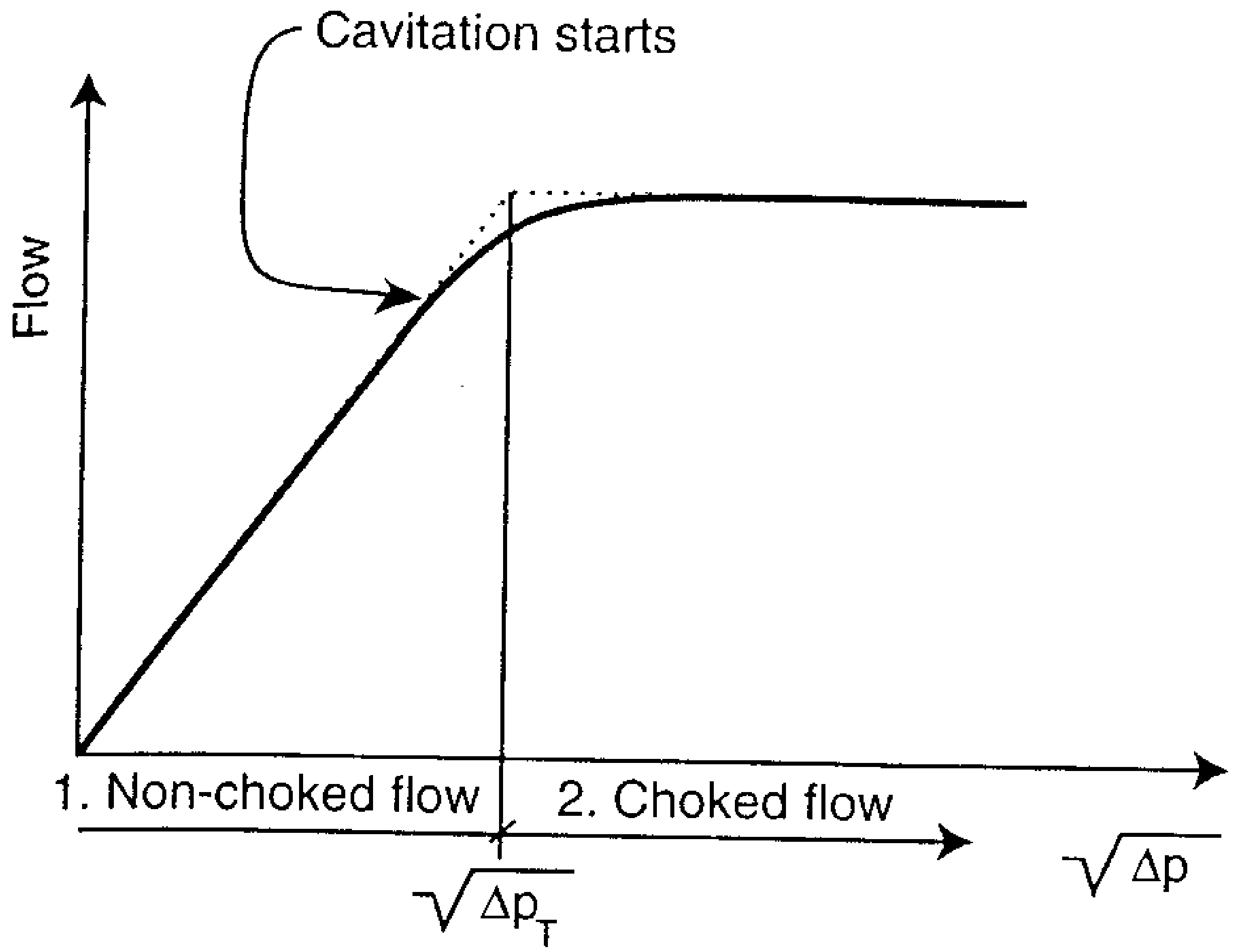
$$\frac{CV(s)}{SP(s)} = \frac{Gp(s)Gv(s)Gc(s)}{1+Gp(s)Gv(s)Gc(s)Gs(s)} \qquad \frac{CV(s)}{D(s)} = \frac{Gd(s)}{1+Gp(s)Gv(s)Gc(s)Gs(s)}$$

Final Control Element

Final Control Element



Final Control Element, flash - cavitation

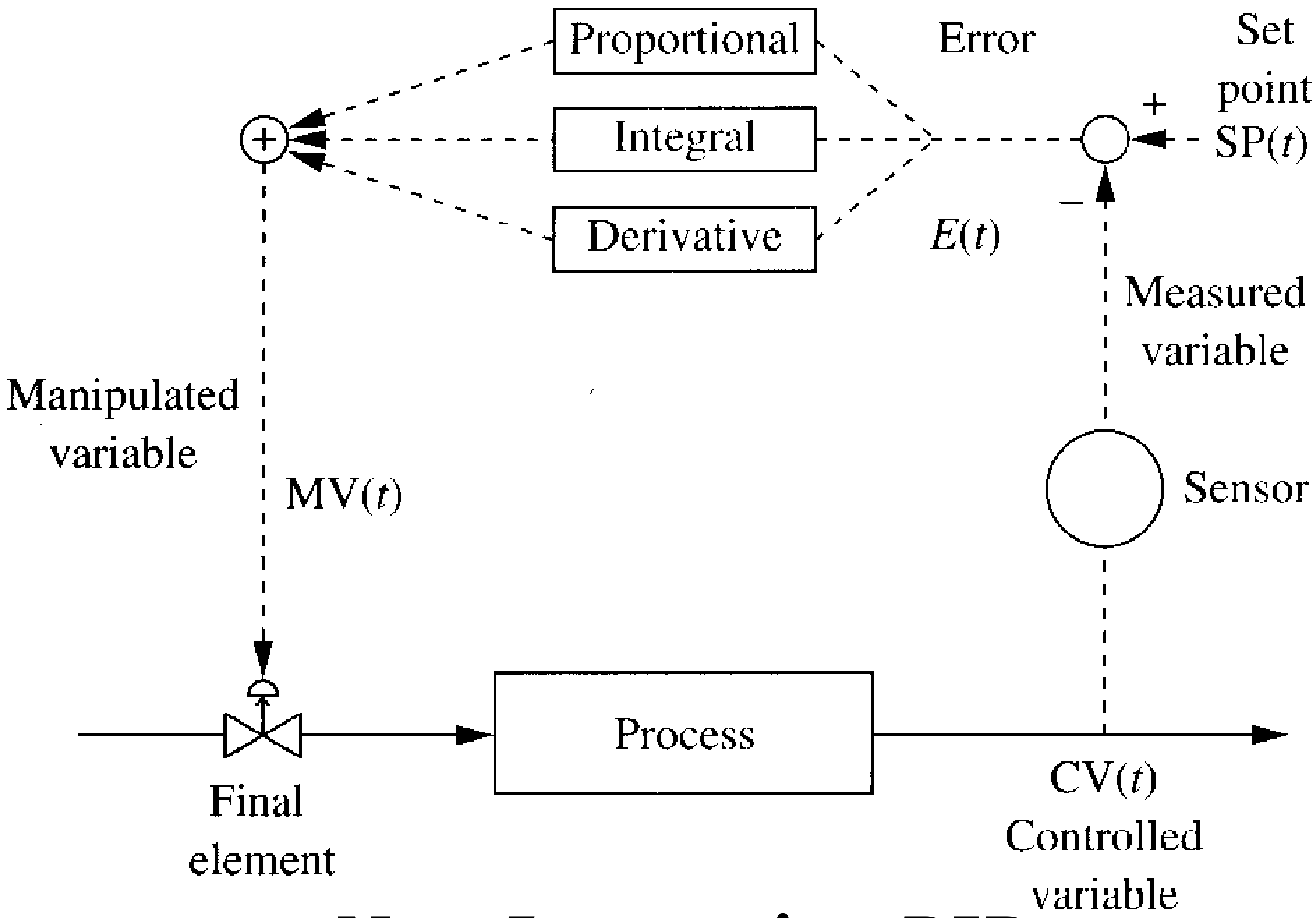


Controller, Conventional Control Modes

Conventional Control Modes, desired features

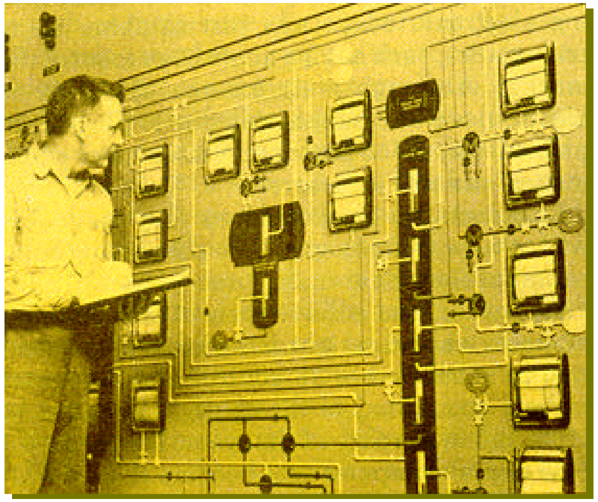
- Zero Offset
- Insensibility to errors
- Wide Applicability
- Simple calculations
- Enhancements

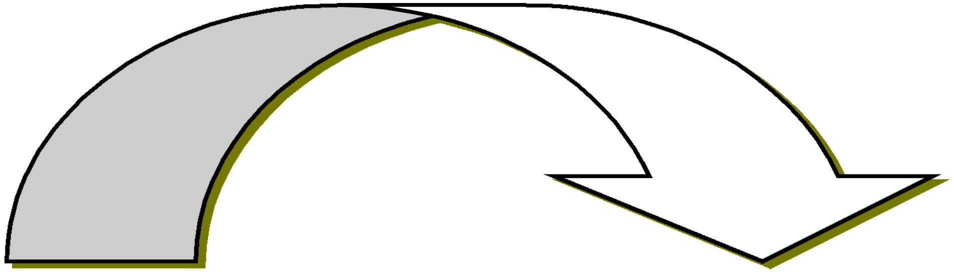
Conventional Control Modes, Control Loop



Non-Interacting PID

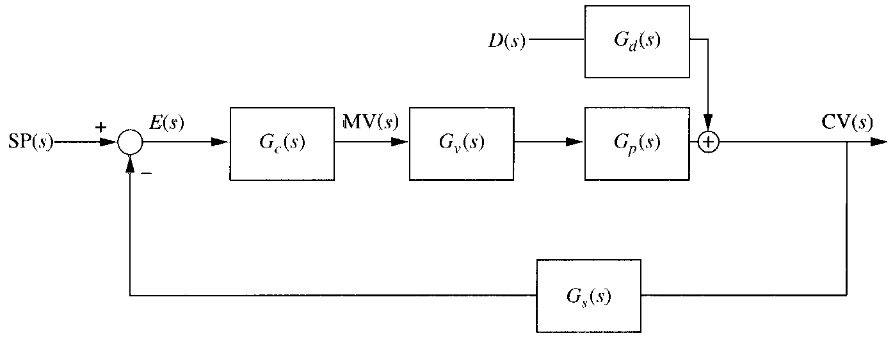
Conventional Control Modes, PID evolution





Conventional Control Modes, Proportional

- Simple
- Normally Stable
- Easy to Tune
- Rapid response
- Offset at steady state
- Increase gain reduces offset but increase instability



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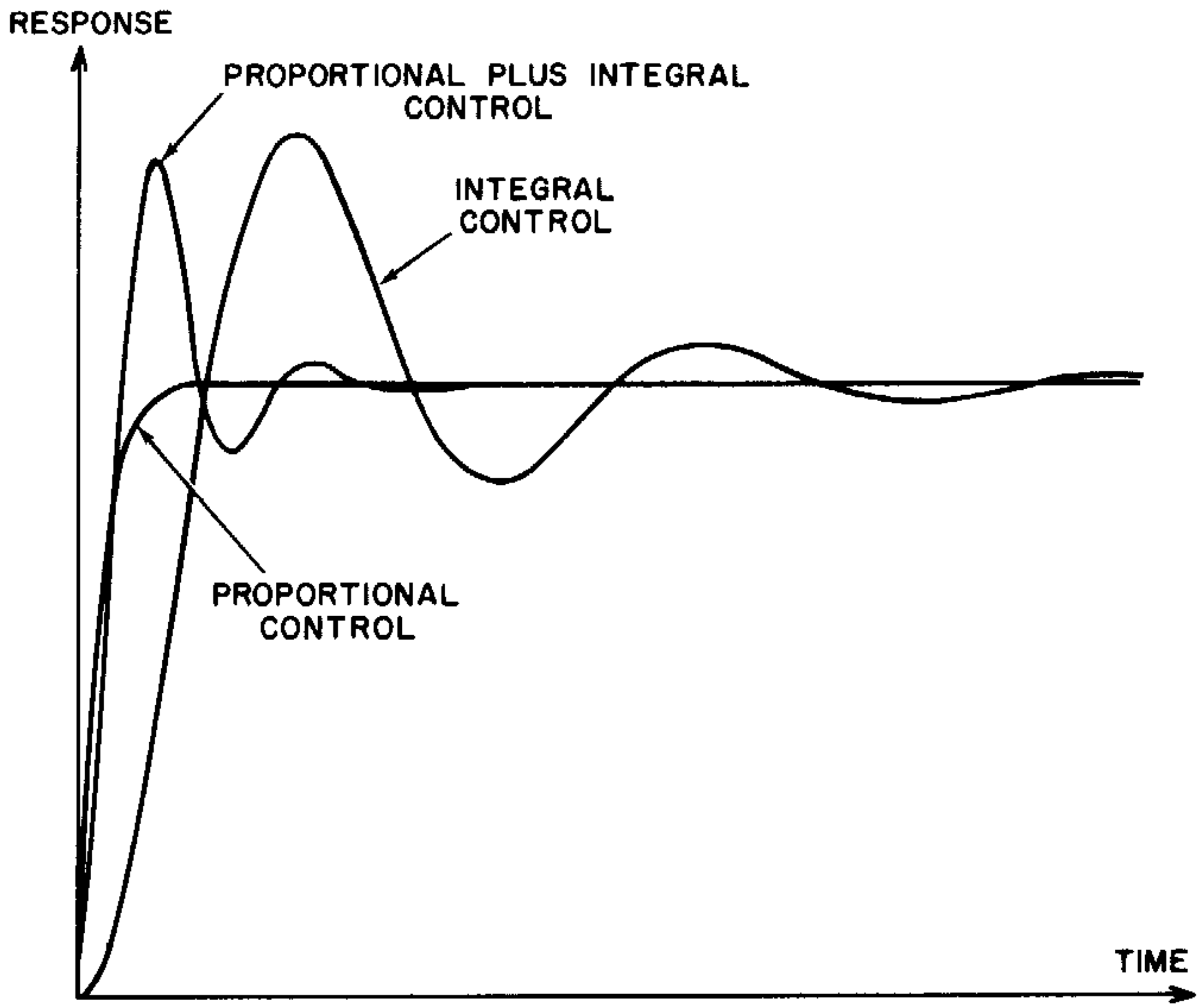
$G_d(s)$ = Disturbance

$$\frac{\mathrm{CV}(s)}{D(s)} = \frac{G_d(s)}{1 + G_p(s)G_v(s)K_c G_s(s)}$$

$$\mathrm{CV}'(t)\,\Big|_{t\to\infty} = \lim_{s\to 0}\left[(s)(\Delta D/s)\frac{K_d\left(\frac{1}{\tau s+1}\right)\left(\frac{1}{\tau s+1}\right)\left(\frac{1}{\tau s+1}\right)}{1 + K_c K_p\left(\frac{1}{\tau s+1}\right)\left(\frac{1}{\tau s+1}\right)\left(\frac{1}{\tau s+1}\right)}\right]$$

$$= \frac{K_d \Delta D}{1 + K_c K_p}$$

Conventional Control Modes

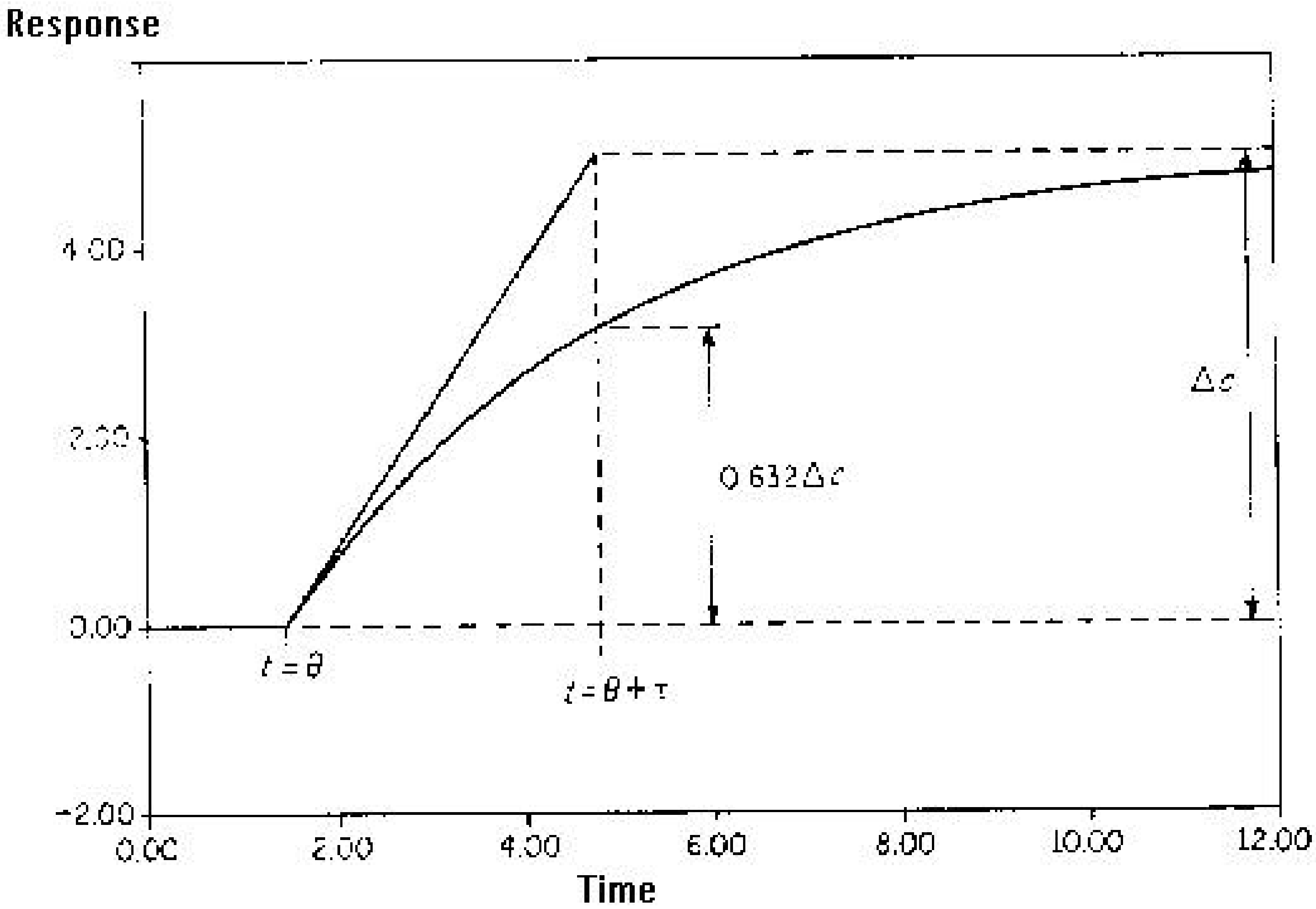


Response to a step change in set point with proportional, integral, and proportional-plus-integral controllers

Process Reaction Curves, General

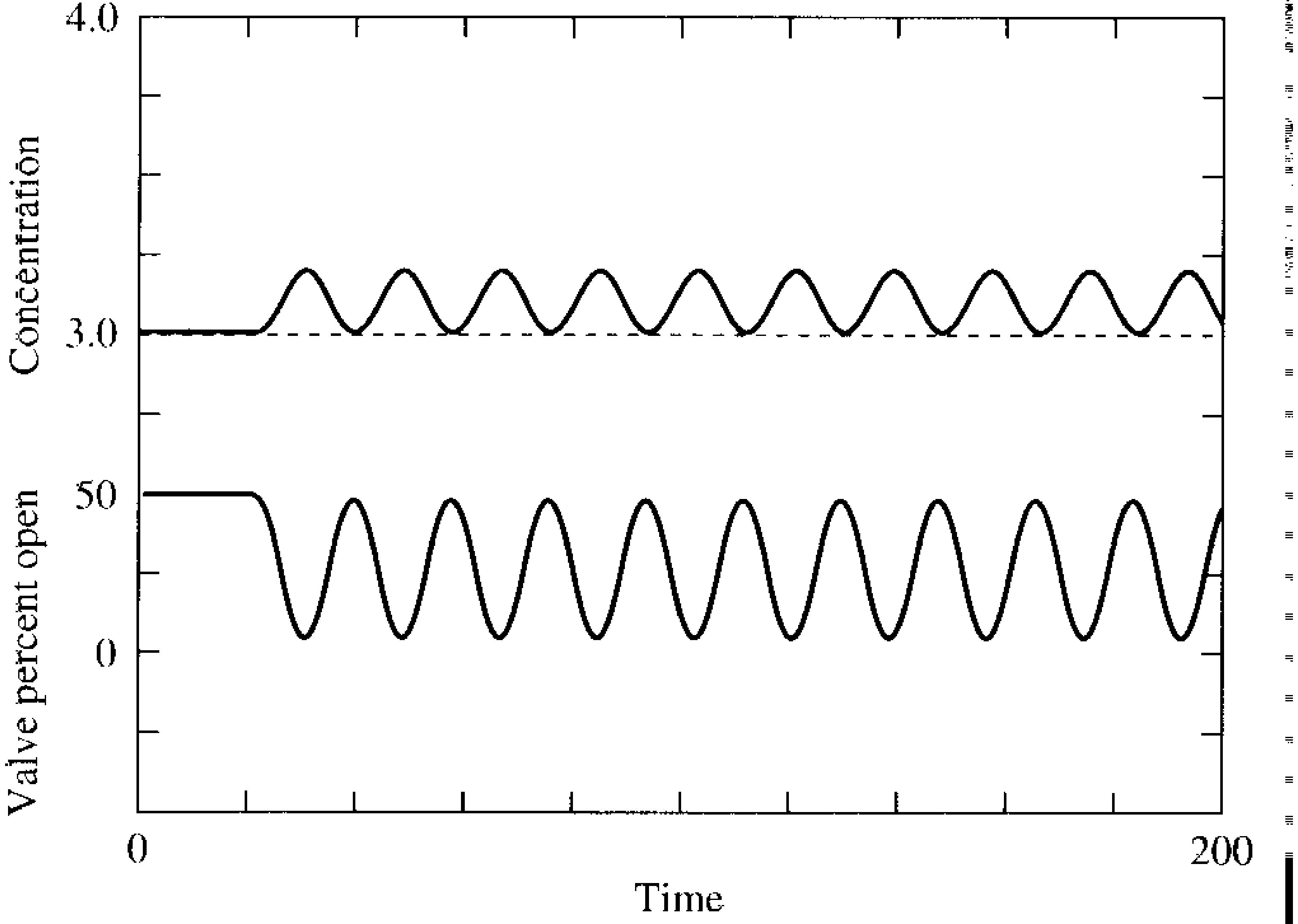
Process Reaction Curves, FOPDT

$$G(s)=\frac{ke^{-Js}}{ts+1}$$



Feedback Controller Tuning

Feedback Controller Tuning, Ultimate Gain



Advanced Classical Controls

- Cascade Control
- Feed forward Control
- Override Controls
- Non-linear Control

Unit Operations single loop controls

Unit Operations single loop controls

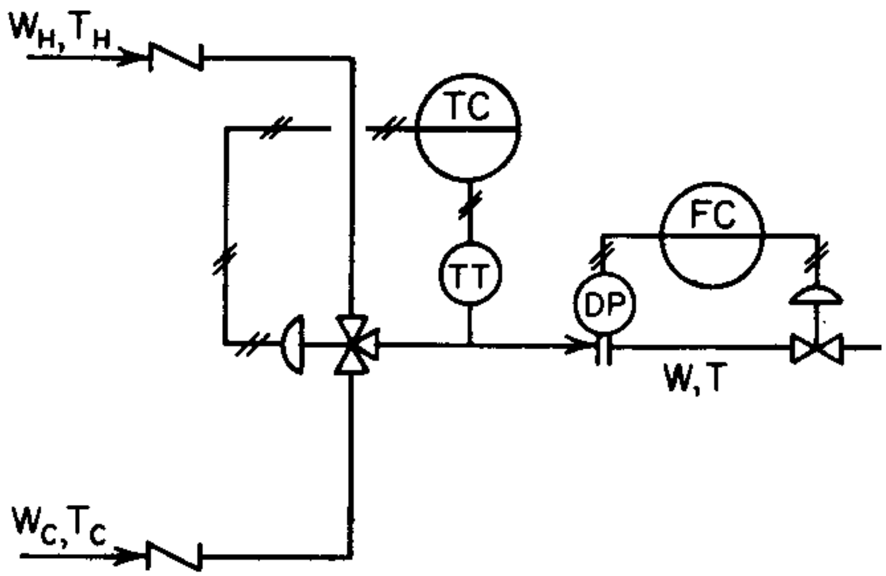
- Flow Control
- Pressure Regulation
- Liquid Level and Inventory
- Temperature Control
- Composition Control
- Considerations
  - Who is the manipulated and controlled fundamental variable
  - What is the main parameter that define the fundamental characteristic of the System

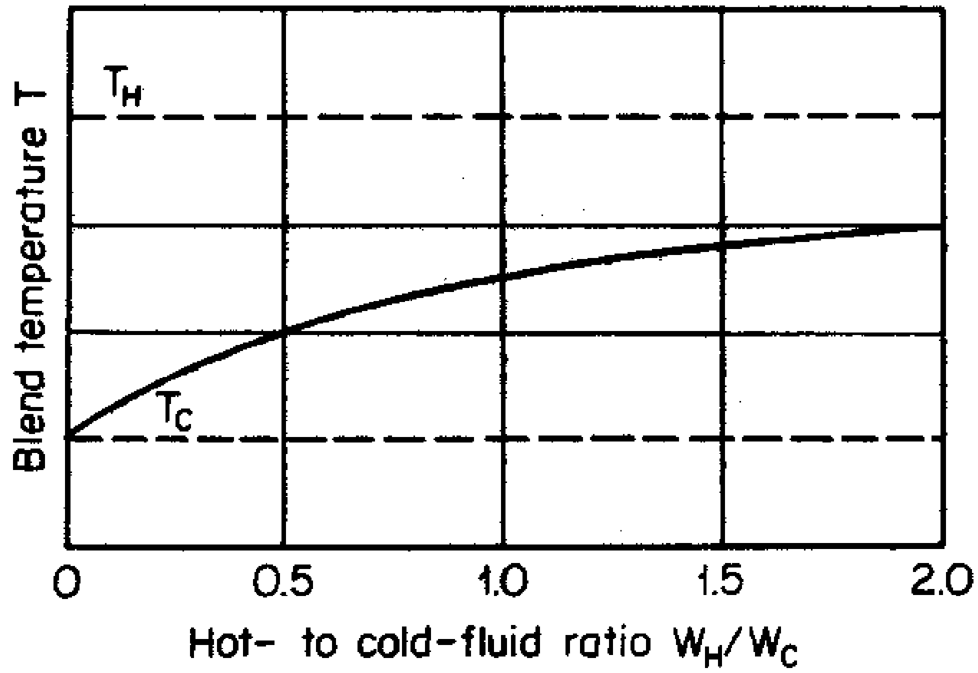
Control of Units Operations

- Heat Transfer
- Product Transport
- Chemical Reactions
- Distillation

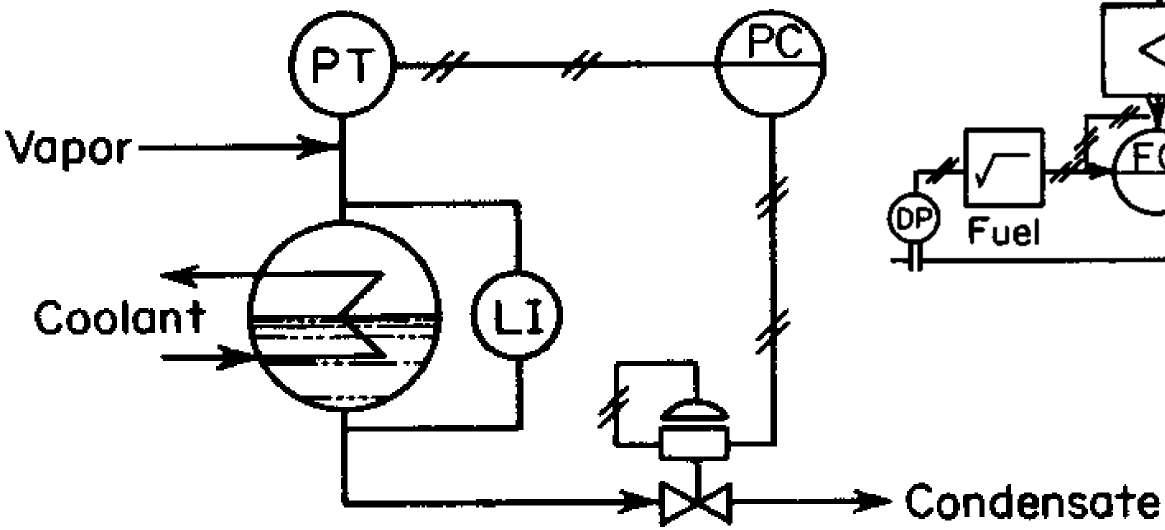
Heat Transfer

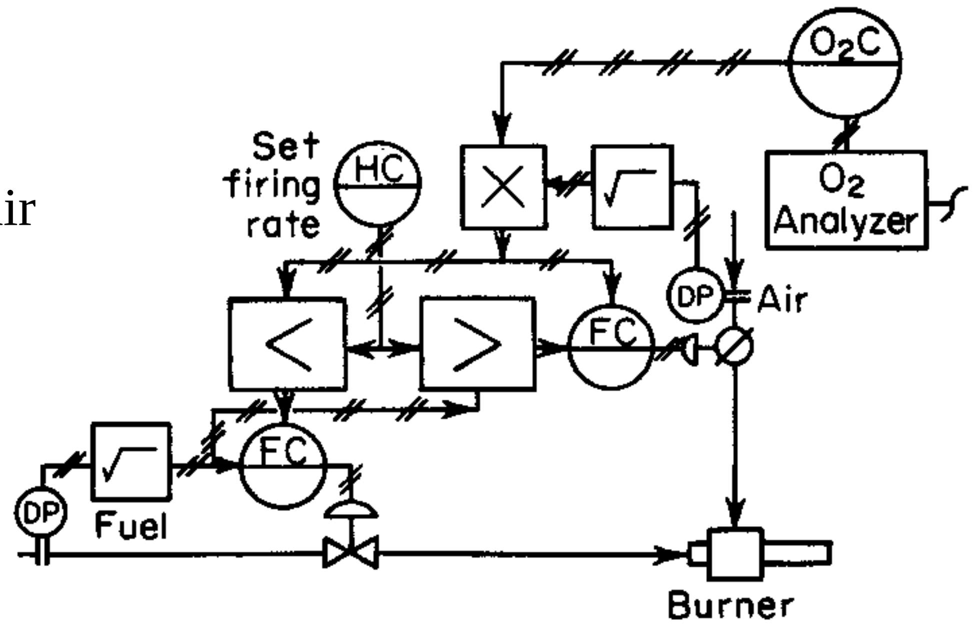
- Mixing exchange
  - Mixing of two fluids to form a single stream
  - Decoupling between temperature and flow, use three way valve
  - Gain changes with the value of flow and temperatures





- Heat exchanger boiling and condensing vapors
- Combustion Control
  - Control of Fuel and Air
  - Control of different fuels
  - Protect against deficiency of air

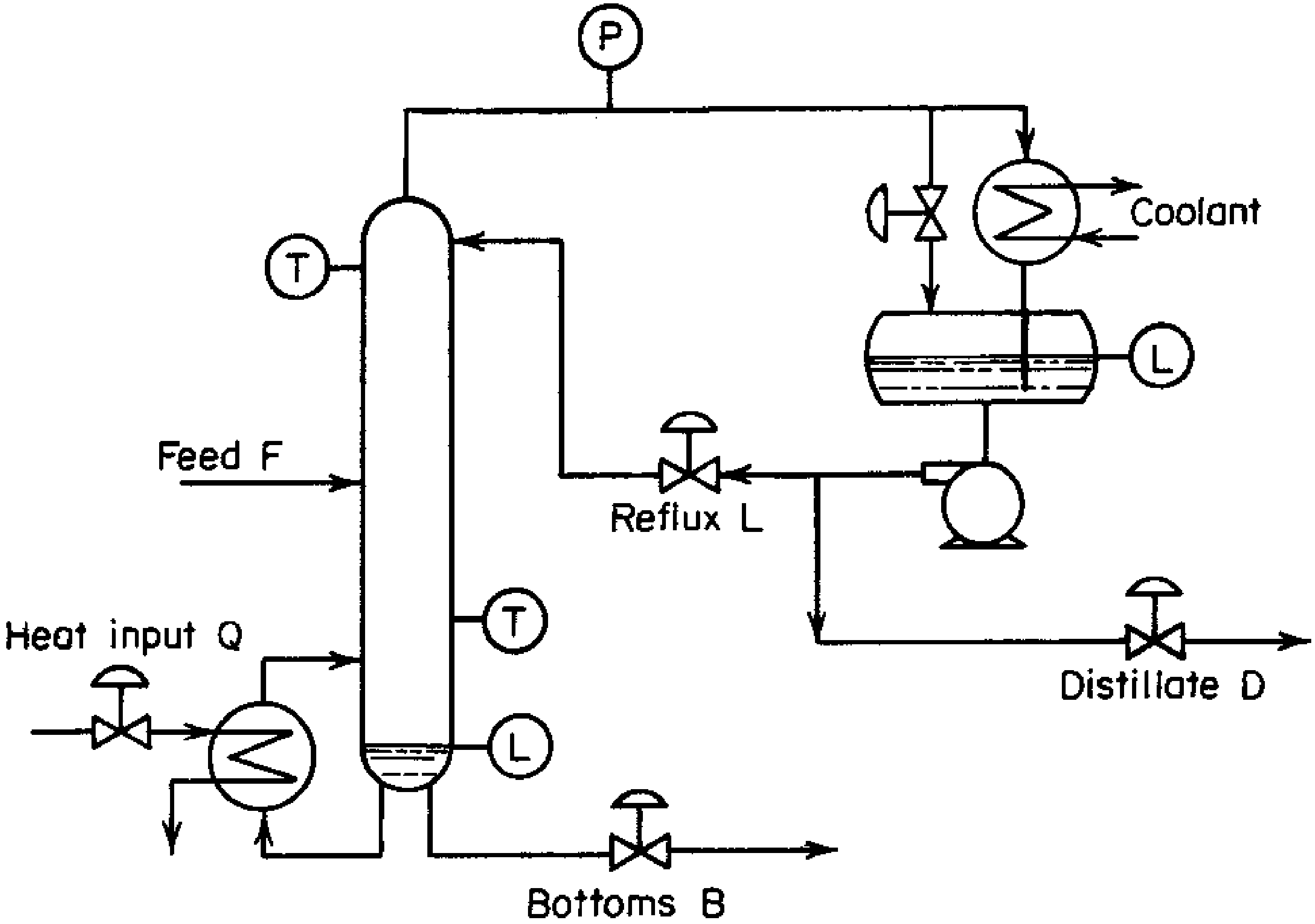




Chemical Reactions

- Reactors. Temperature Control
  - Reactors are difficult pieces of equipment and its control depend strongly on the reactor type, design and reaction characteristics.
  - Strong temperature influence makes endothermic reactors self regulating and exothermic reactors stability problems (positive feedback)
- Recommendations
  - Maintain a heat removal capacity greater than the maximum heat generation capacity for stability
  - To reduce dead time maintain maximum coolant flow
  - Use Reactor temperature control cascade to coolant temperature and use derivative action

Distillation


P
T
Coolant
L
Feed F
Reflux L
T
Heat input Q
L
Distillate D
Bottoms B

- Characteristics
  - Distillation achieves separation by counter current contacting vapor and liquid. Reflux gives the liquid and reboiler gives the vapor.
  - **Disturbances**
    - Feed flow, temperature, composition, enthalpy
    - Heating medium property variation, i.e., steam pressure
    - Coolant medium property variation, i.e., ambient temperature
  - **Condenser**. Maximum capacity as a function of DT and fouling, condensing capacity increase with pressure
  - **Reboiler**. Maximum capacity as a function of DT and fouling. Increasing pressure rises capacity
  - **Column**
    - Maximum vapor rate rises with column pressure, and drops with liquid flow. Minimum is weeping
    - Maximum liquid rate rises lowering pressure

Control of Units Operations, Distillation, composition

- Indirect measurements. Temperature control
  - Improve indirect composition via pressure compensation