SKF 3143

Process Control and Dynamics: Control of Chemical Processes

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Learning Objectives

When I complete this chapter, I want to be able to do the following:

1. identify main control variables and their application
2. classify type of variables in chemical processes

Outline of this lecture

1. **Typical Control Variables**
2. **Common Unit Operations**
3. **Classification of Variables**

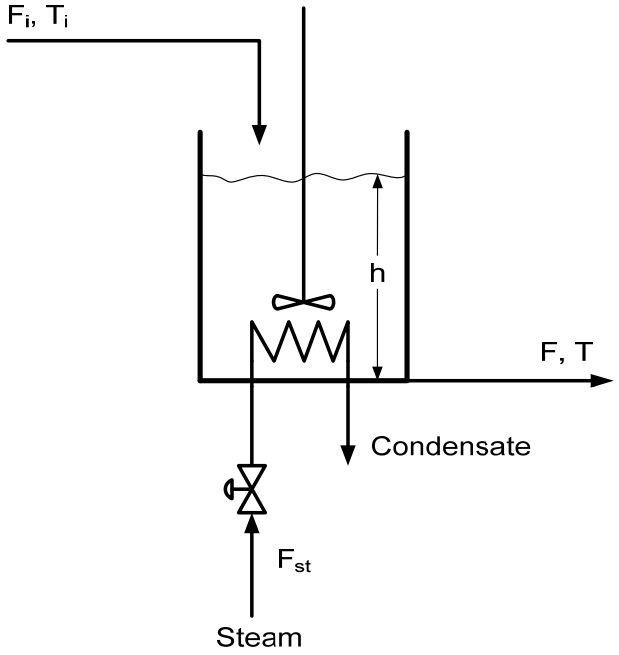
Chemical process variables.

Typical control variables.

TYPICAL CONTROL VARIABLES

Chemical process variables.

- Variables such as flow rates, temperatures, pressures, volumes, pHs, viscosities and concentrations can be divided in to two groups
  - Input Variables: Effect of surroundings on the chemical process
  - Output Variables: Effect of chemical process on the surroundings



- Input Variables: F_i, T_i, F_{st}, (F)
- Output Variables: F, V or h, T

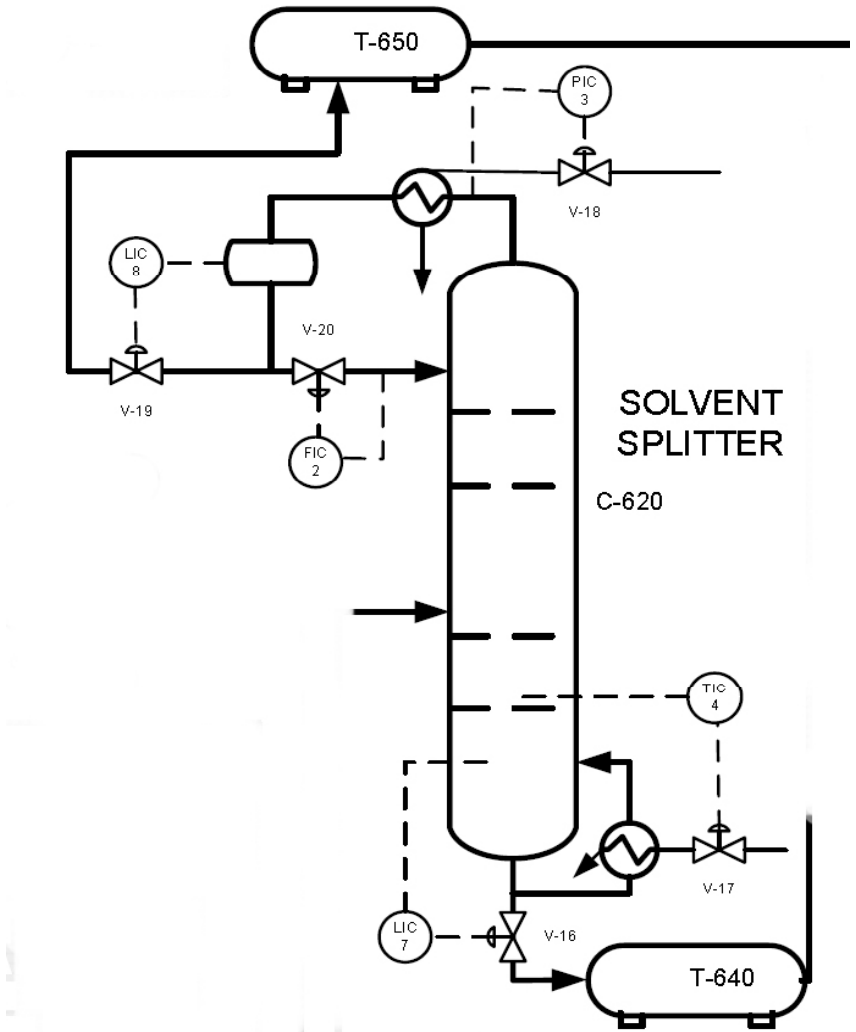
Input Variable

- Manipulated: their values can be adjusted freely by control mechanism (F_{st} and F)
- Disturbances: values are not the result of adjustment by control mechanism (F_i and T_i)

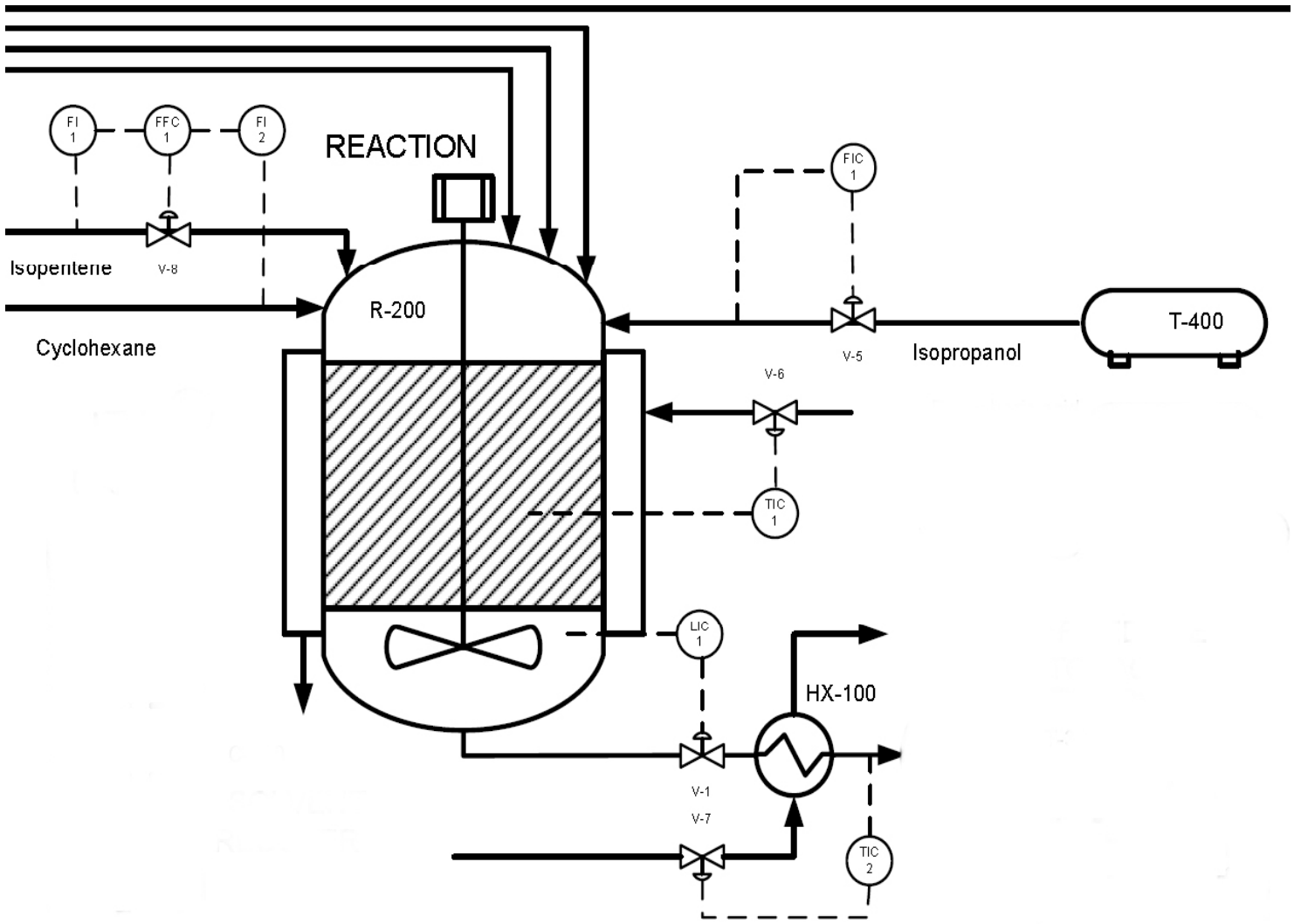
Output Variable

- Measured: values are known by directly measuring them (V and T)
- Unmeasured: cannot be measured directly

Exercise: Typical control variables for Solvent Splitter.



Exercise: Typical control variables for Polymerization Reactor.

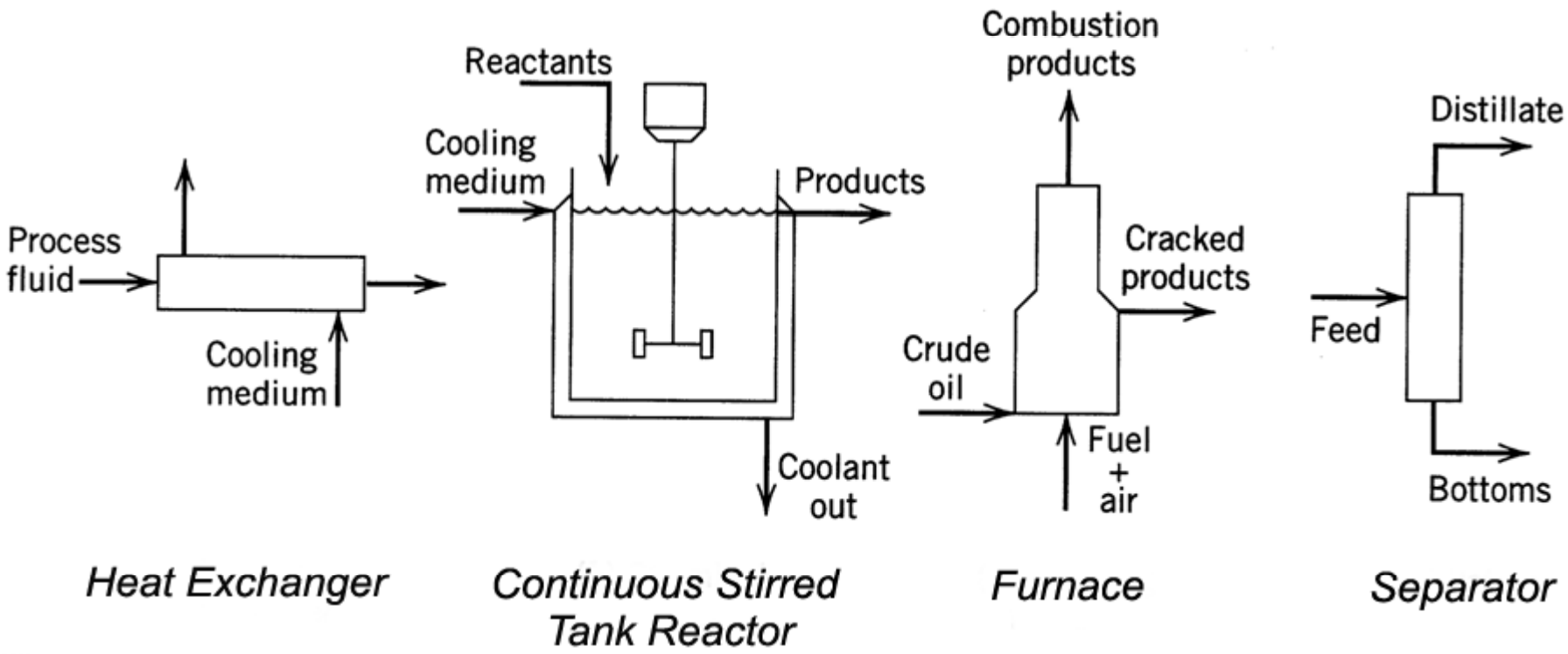


Some typical continuous processes.

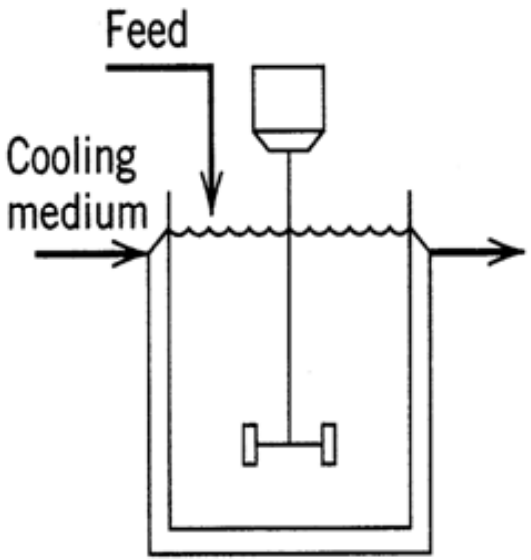
Some typical noncontinuous processes.

COMMON UNIT OPERATIONS

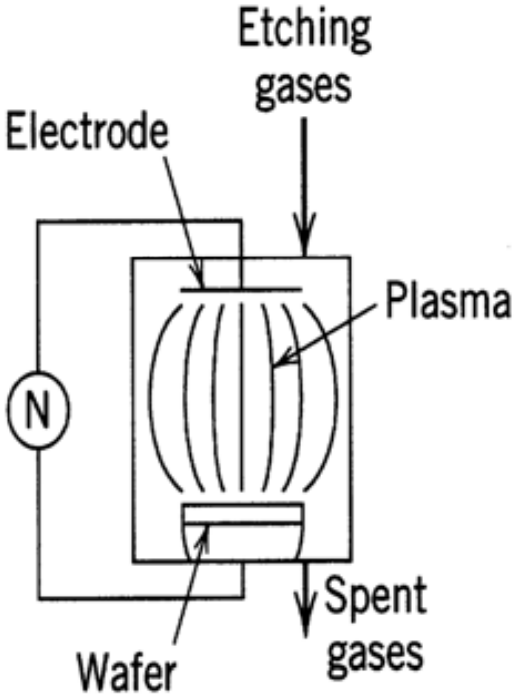
Some typical continuous processes.



Some typical noncontinuous processes.



Semi Batch Reactor



Plasma Etcher

Chemical process variables.

Design elements of control system.

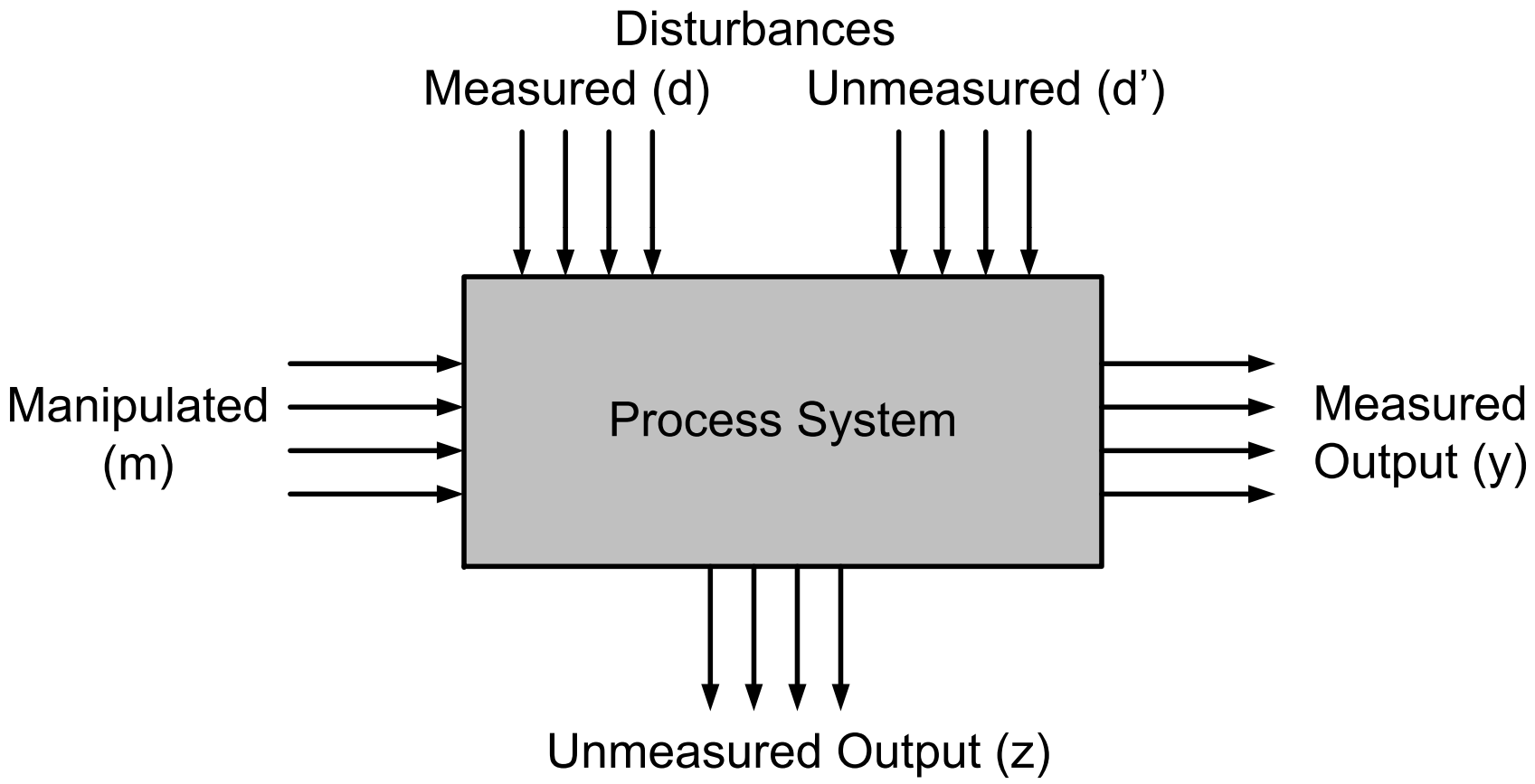
Selecting measurements.

Selecting manipulated variables.

Selecting controller configuration

CLASSIFICATION OF VARIABLES

Chemical process variables.

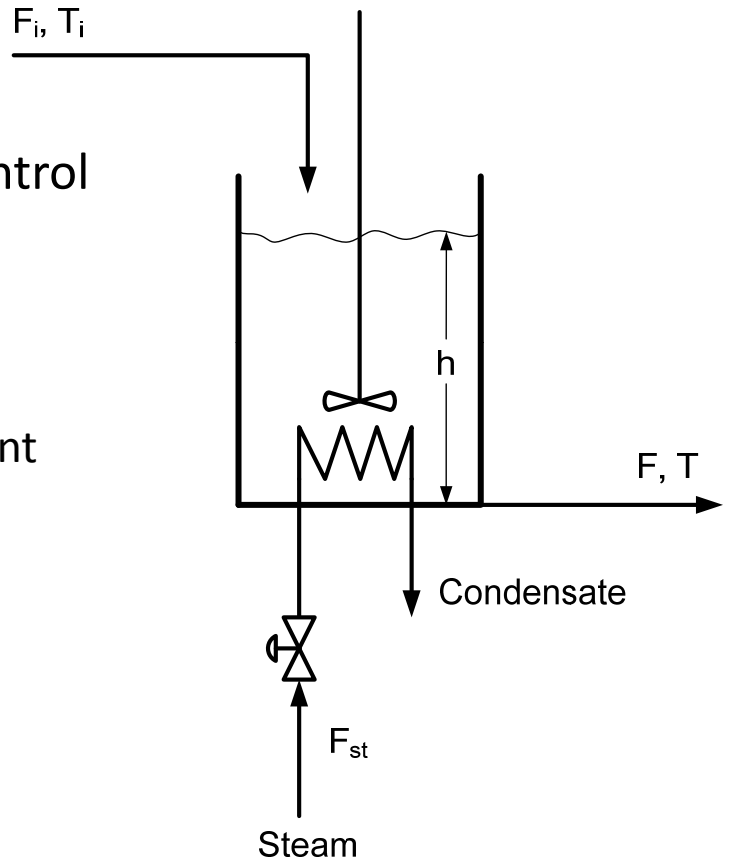


Design elements of control system.

Define control objectives

- What are the operational objectives that a control system is called upon to achieve
  - Ensuring the stability of the process
  - Suppressing the external disturbances
  - Optimising the economic performance of a plant
  - A combination of the above

- For the example, the control objectives
  - To control the temperature and volume
  - $T = T_s$
  - $V = V_s$
  - Where T_s and V_s are the desired values



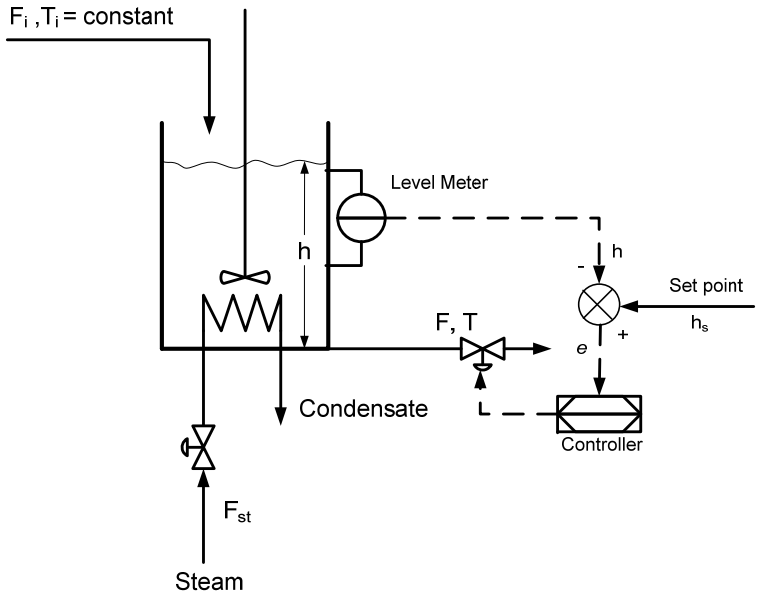
Selecting measurements.

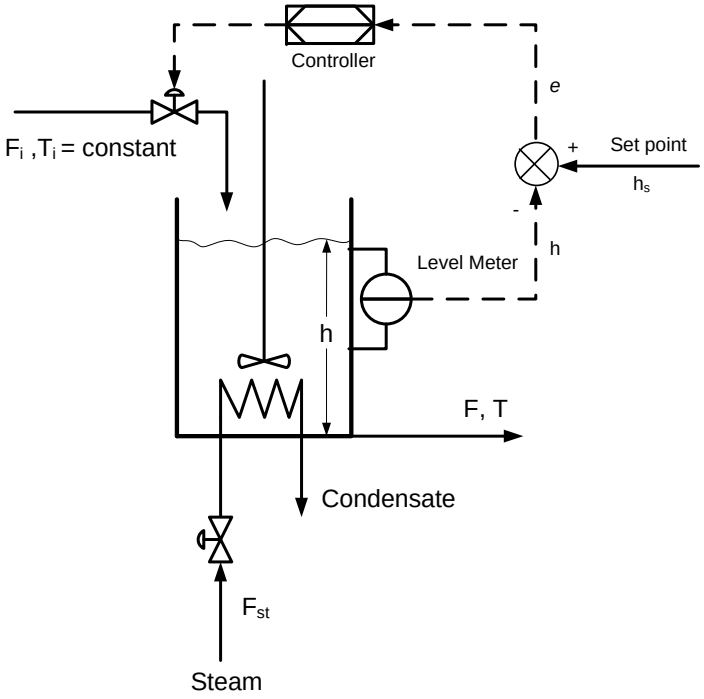
- Selecting measurement
  - We need some means to monitor the performance of the chemical process
  - This is done by measuring the values of certain processing variables (temperature, pressures, concentration, flow rates, pH)

- What variables should we measure in order to monitor the operational performance of a plant?
  - For tank heating system our control objectives are to keep the volume and temperature at desired value
  - Thus we have to measure
    - Temperature (T) using thermocouple
    - Volume (V) using Differential Pressure Cell (DPC)

Selecting manipulated variables.

- What are the manipulated variables to be used to control a chemical process?
  - Usually we have several options to choose (F_i or F)
  - The selection is very crucial because it will affect the quality of the control action

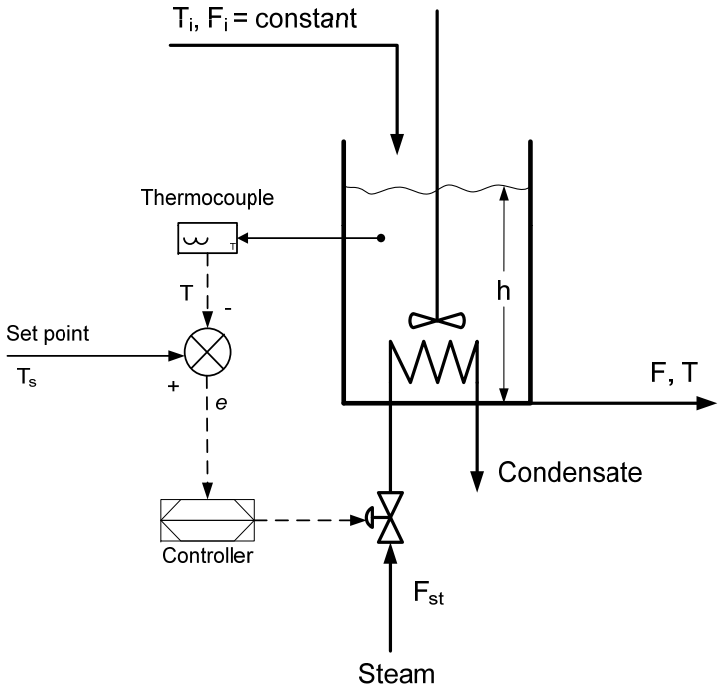




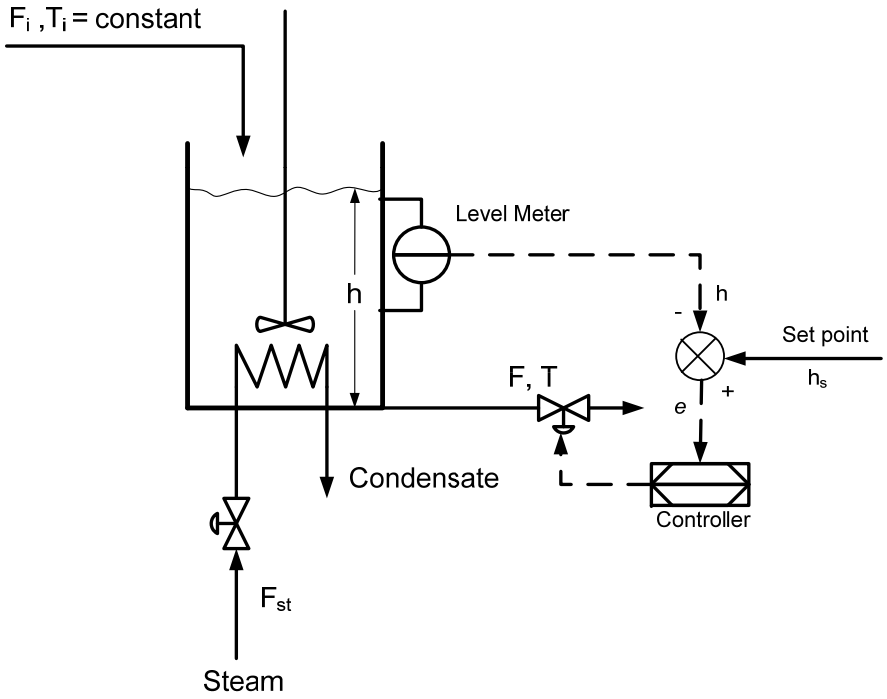
Selecting controller configuration

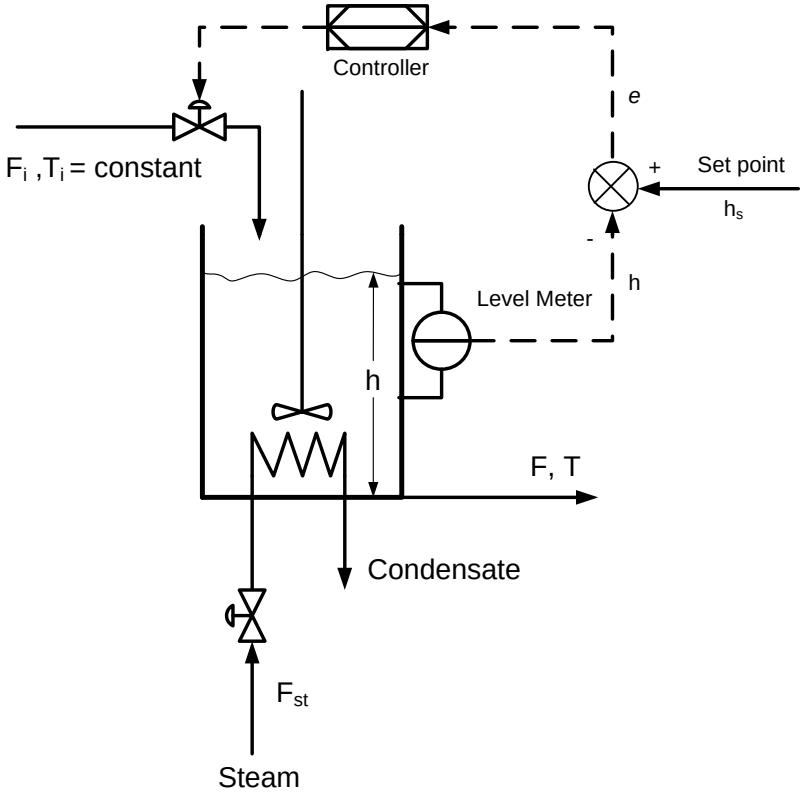
- Feedback control constitute two different control configuration:
  - Same information flows to different manipulated variables
  - Same manipulated variables but different measurement

- Control Structure
  - Information structure that is used to connect the available measurements to the available manipulated variables



Same information but different manipulated variables.

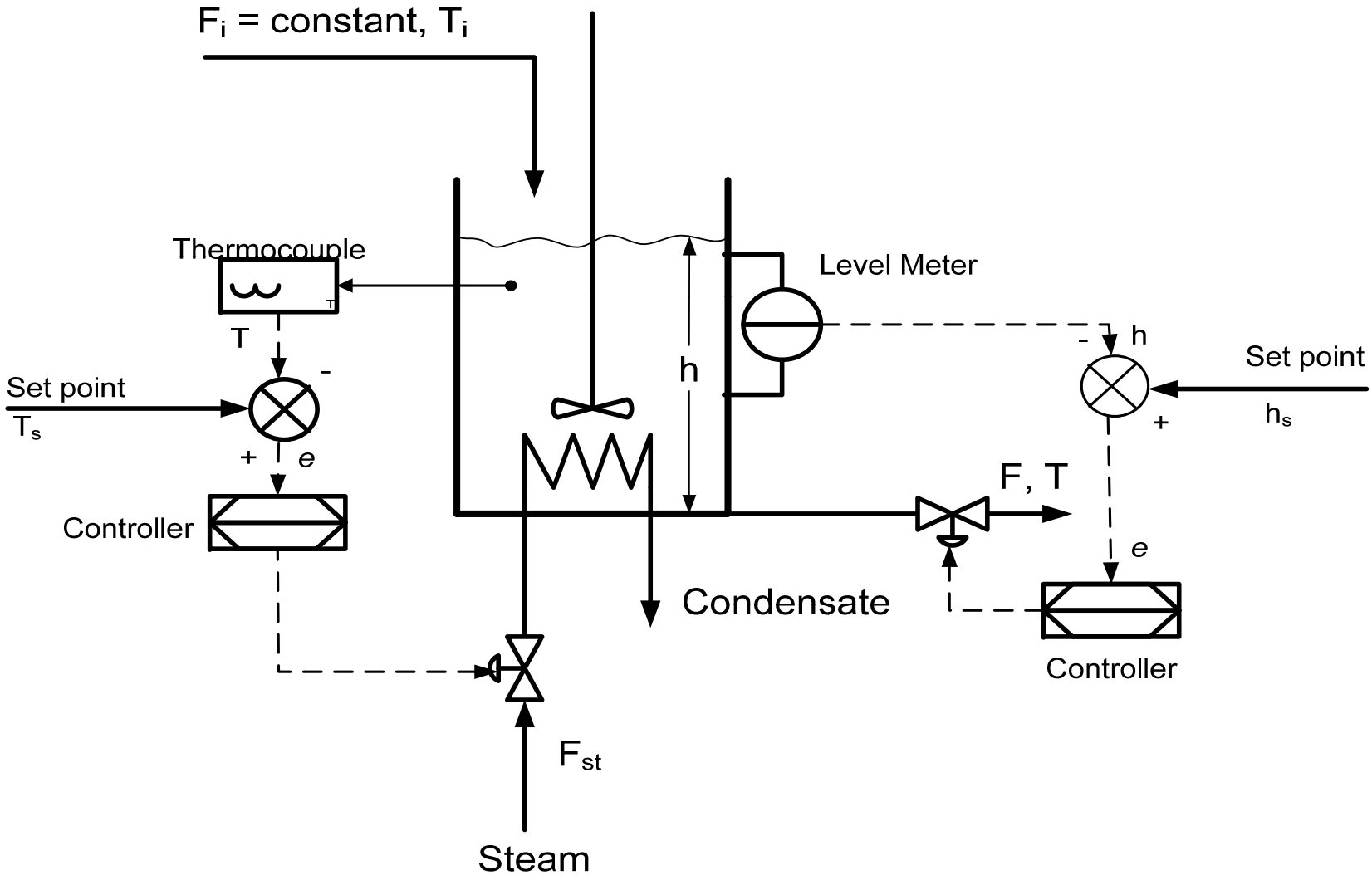




Controller configuration.

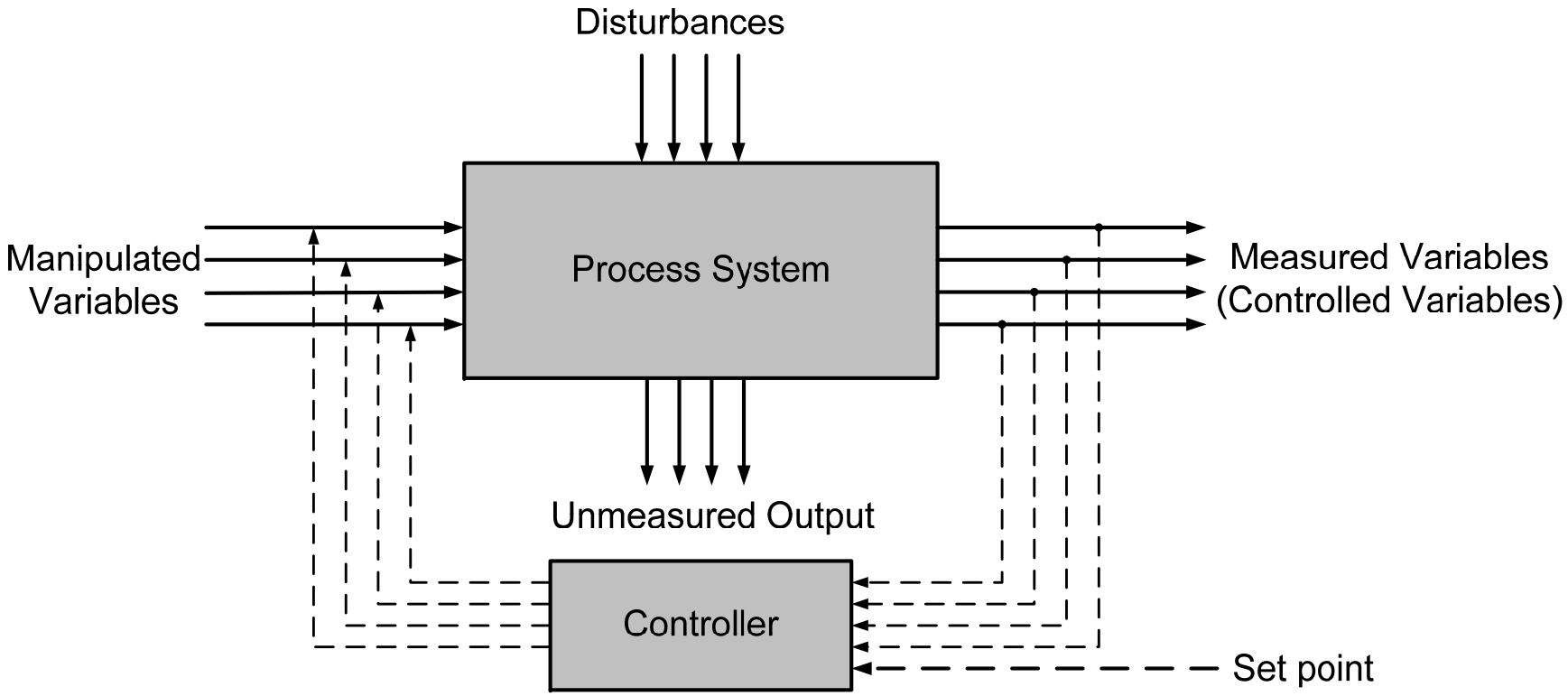
- What is the best control configuration for a given process control situation?
  - The answer for this is very critical for the quality of the control system we are to design
- Controller Configuration
  - SISO – single input single output
  - MIMO – multiple input multiple output
- For heated tank system
  - If the control objectives is to keep the level at a desired value by manipulating the effluent flow rate, we have a SISO system
  - If the control objectives are to control level and temperature, we have MIMO system.

MIMO controller.

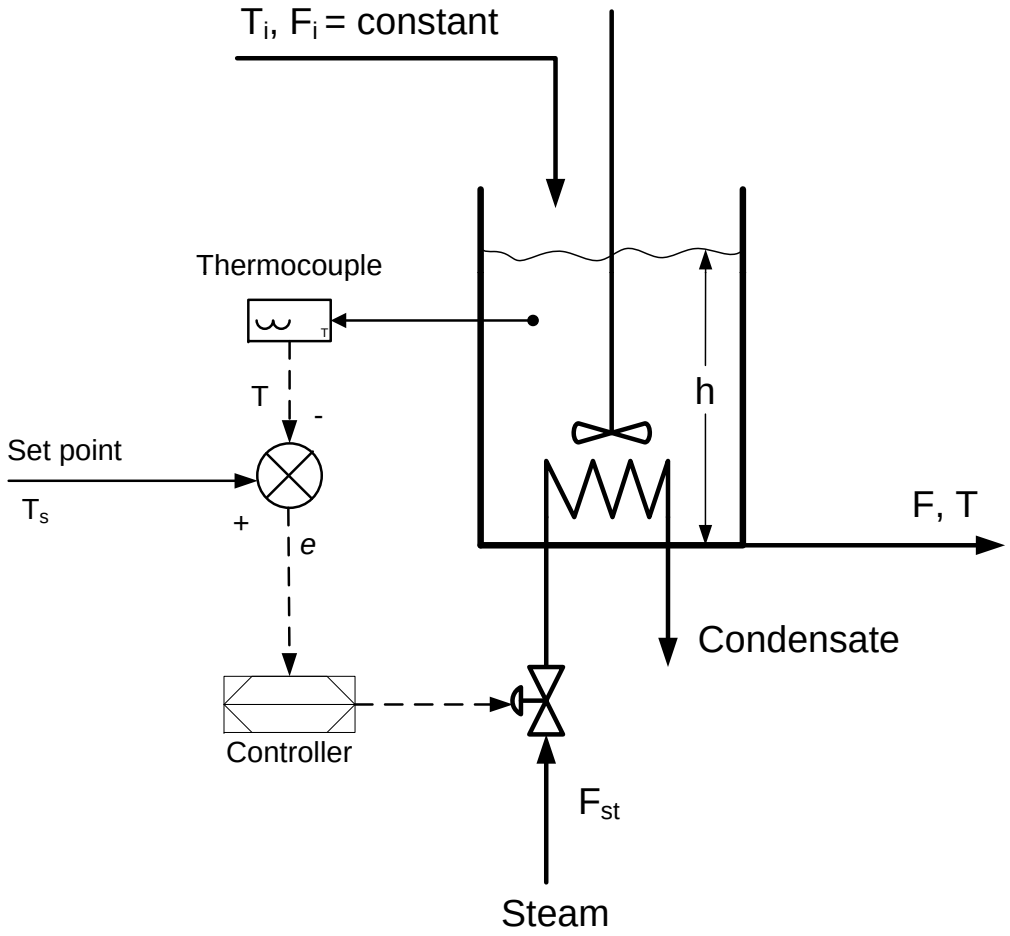


Feedback Controller

- Uses direct measurements of the controlled variables to adjust the values of the manipulated variables
- Objectives: to keep the controlled variables at desired levels (set points)

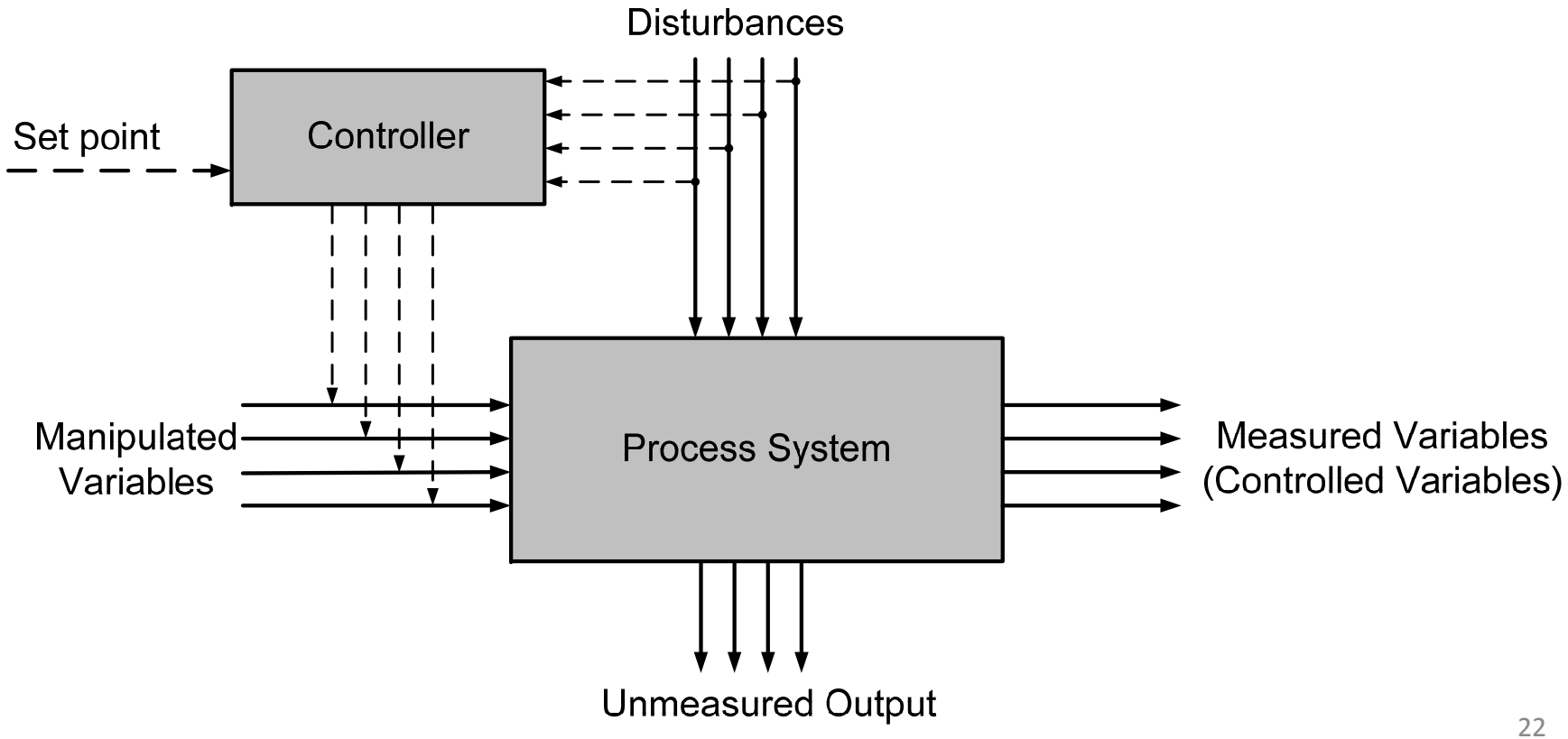


Feedback Control for Temperature

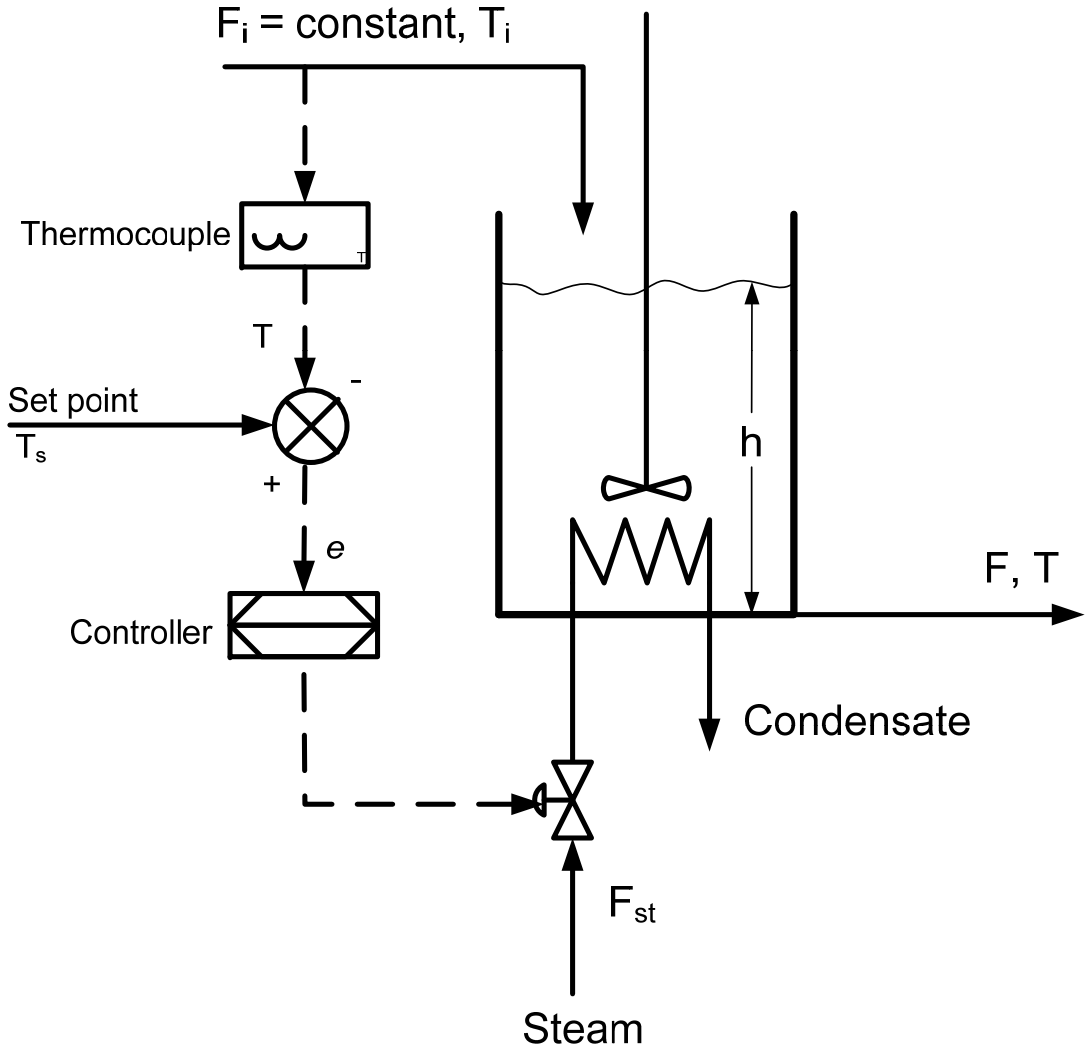


Feedforward Controller

- Uses direct measurement of the disturbances to adjust manipulated variables
- The objective here is to keep the values of the controlled output variables at desired levels

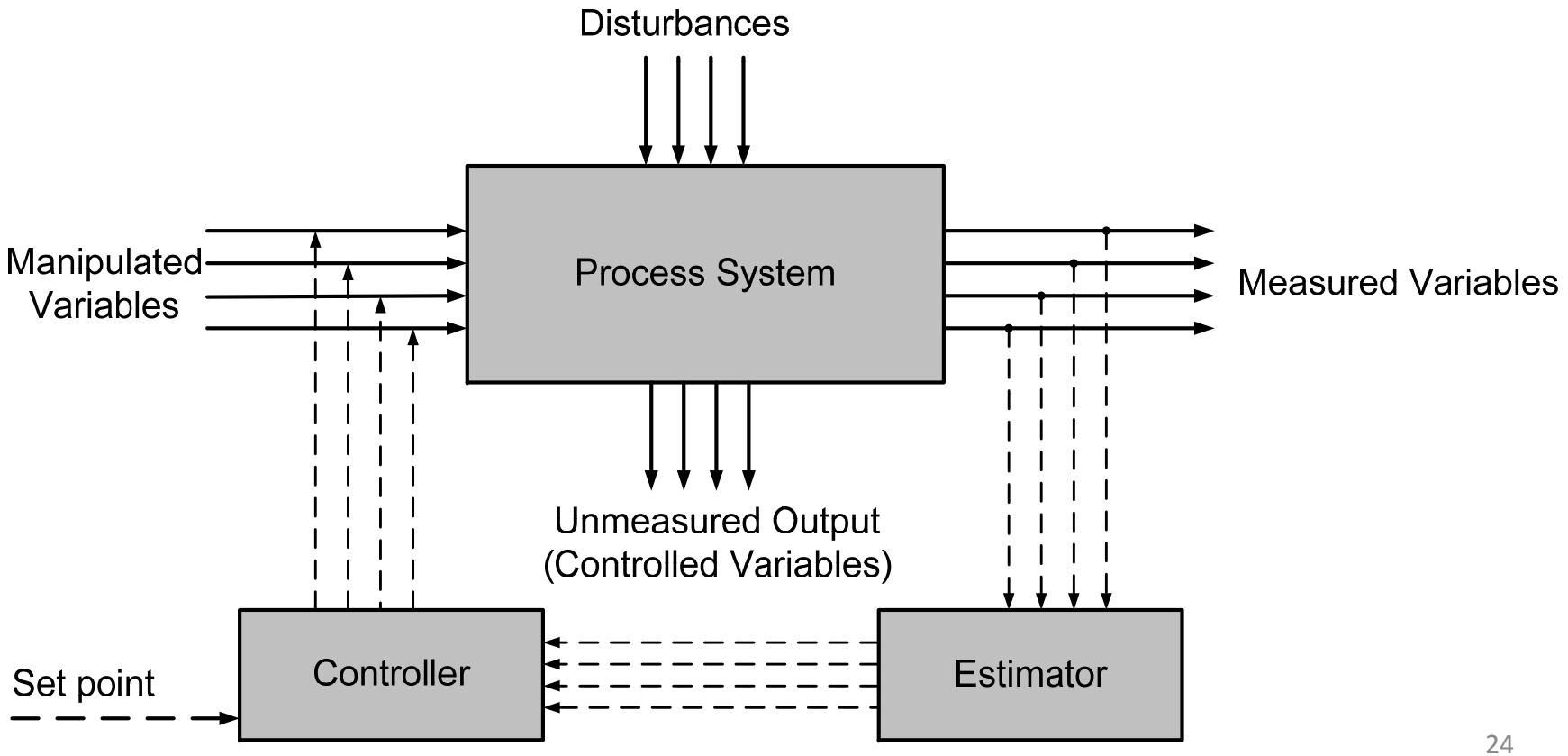


Feedforward Controller for Temperature



Inferential Controller Configuration

- Uses secondary measurements to adjust the manipulated variables because the controlled variables cannot be measured
- Control objective here is to keep the unmeasured controlled variables at desired levels



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- Stephanopoulos, G. (1984). *Chemical Process Control. An Introduction to Theory and Practice*. Prentice Hall, ISBN: 978-01-31286-29-0