SE418: Industrial Process Control

Lecture 1

Introduction to Process Control

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Outlines

- What is a process?
- What is process control?
- Why process control is needed?
- Outlines of the Course
- Example of processes
  - Continuous
  - Batch

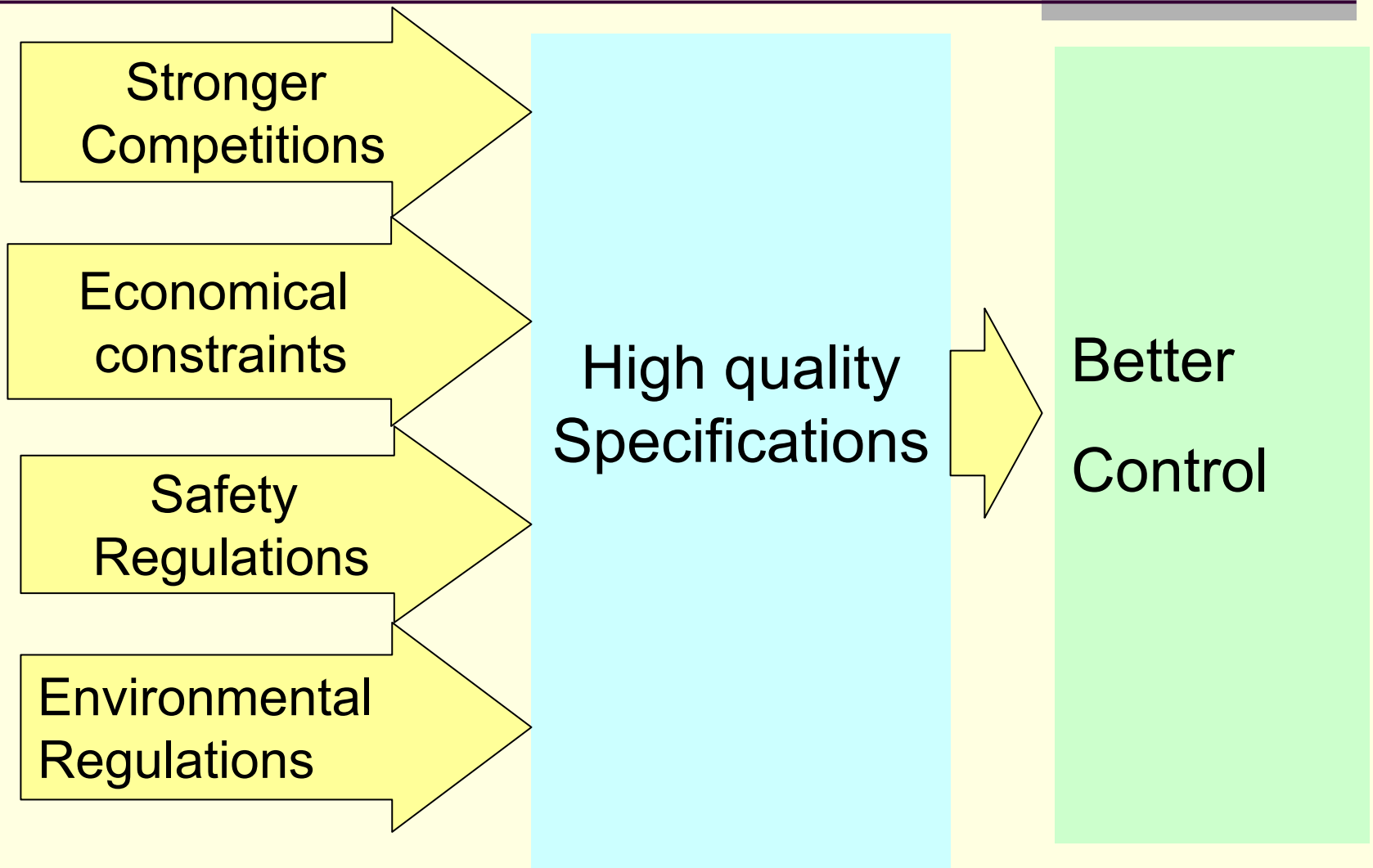
What is a process?

- Process: “ The Conversion of a feed material into a product using chemical and physical operations“
- Process is often used to mean
  - The processing operation
  - The processing equipment

Course Objectives

- Obtain theoretical and empirical mathematical models of different processes
- To analyze the dynamic behavior of processes and develop good understanding of their behavior in different situations
- To design different types of controllers

Key Factor for Better Process Control



Objectives of Process Control

- To maintain the process at desired operating conditions safely and efficiently while satisfying environmental and product quality requirements.

Why Process Control is needed?

Specific Objectives of Control

- Increased product throughput
- Increased yield of higher valued products
- Decreased energy consumption
- Decreased pollution
- Decreased off-spec product
- Increased Safety
- Extended life of equipment
- Improved Operability
- Decreased production labor

Control Engineering Terminology

- **Controlled Variables (CV)**
- **Manipulated Variables (MV)**
- **Disturbance Variables (DV)**
- **Set-Point (SP)**

Controlled Variables (CV)

- **controlled variables -** these are the variables which quantify the performance or quality of the final product
- also called output variables.

Manipulated Variables (MV)

- **manipulated variables -** these input variables are adjusted dynamically to keep the controlled variables at their set-points.

Disturbance Variables (DV)

- **disturbance variables -** represent input variables that can cause the controlled variables to deviate from their respective set points
- also called "load" variables
- DV are not adjusted
- DV may or may not be measured

Set Point (SP)

- Set Point signal = desired level of a controlled variable
- To implement a change in the operating conditions, the set-point signal is changed and the manipulated variable is adjusted appropriately to achieve the new operating conditions.

Common types of processes

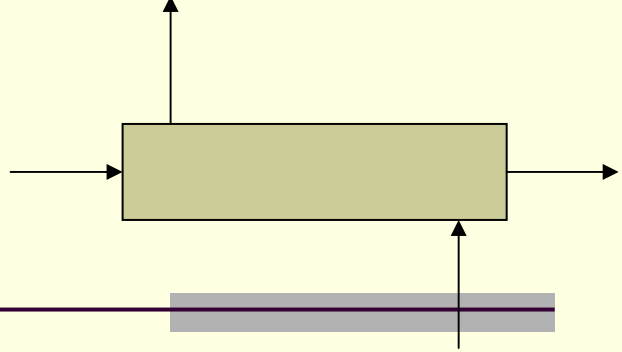
- Continuous Process
  - The input and output flow continuously throughout the duration of the process
- Batch Process
  - The feed is charged into a vessel at the beginning of the process then the vessel's content is removed some time later
- Semi-Batch Process:
  - It is neither batch nor continuous

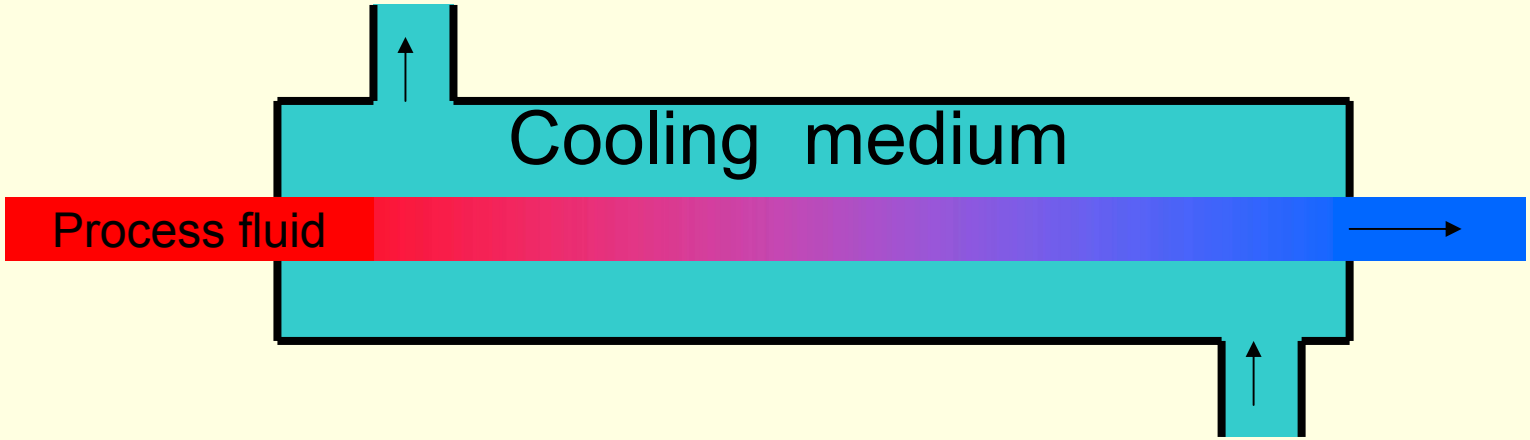
Examples of Continuous Process

- Heat Exchanger
- Chemical Reactor
- Cracking Furnace
- Distillation Column

Continuous Process

Tubular Heat exchanger

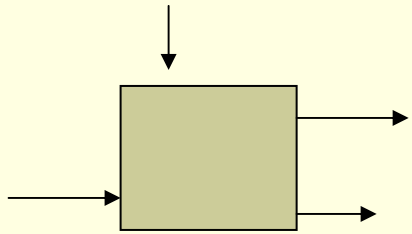


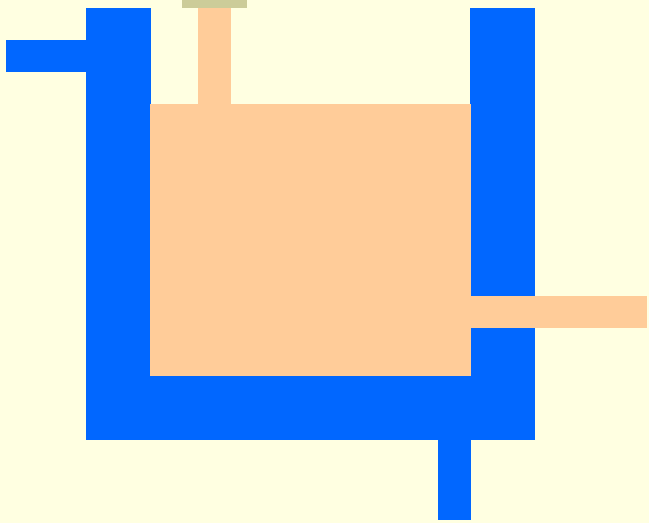


- Process fluid is cooled by cooling water
- CV: exit temperature of process fluid
- MV: flow rate of cooling water
- DV: inlet temperature, inlet flow rate,…

Continuous Process

Chemical Reactor

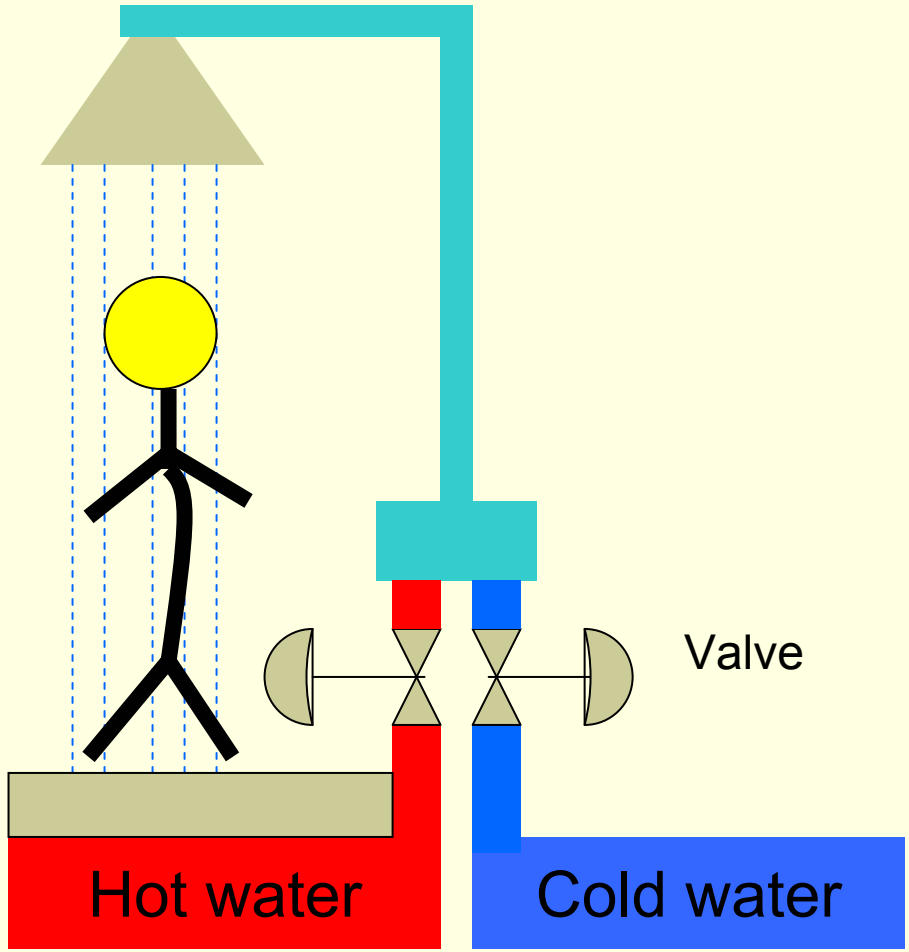




Mixing Process

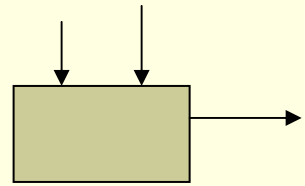
Shower Example

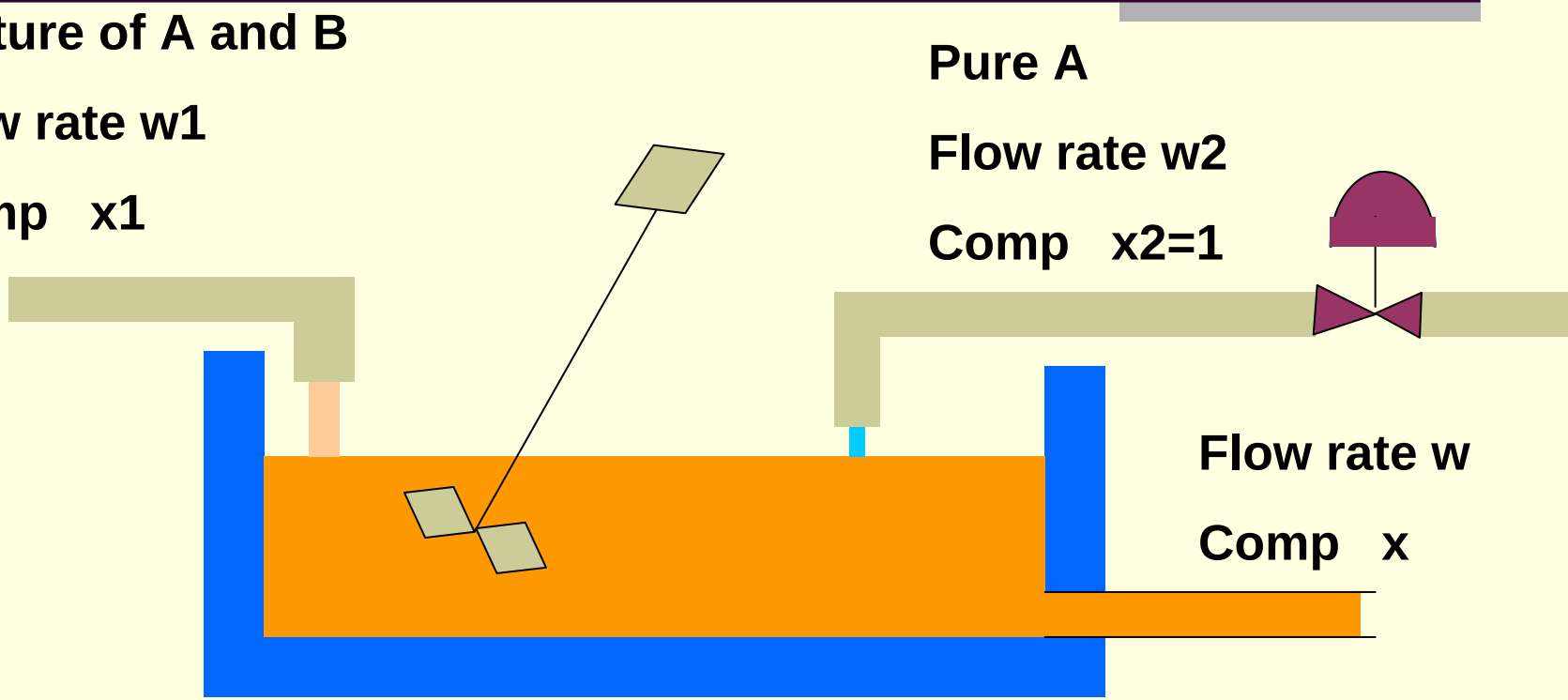
- Hot and cold water are mixed
- Time delay is introduced
- Delay is the time needed for water to travel between the mixer and the person



Continuous Process

Mixing Process





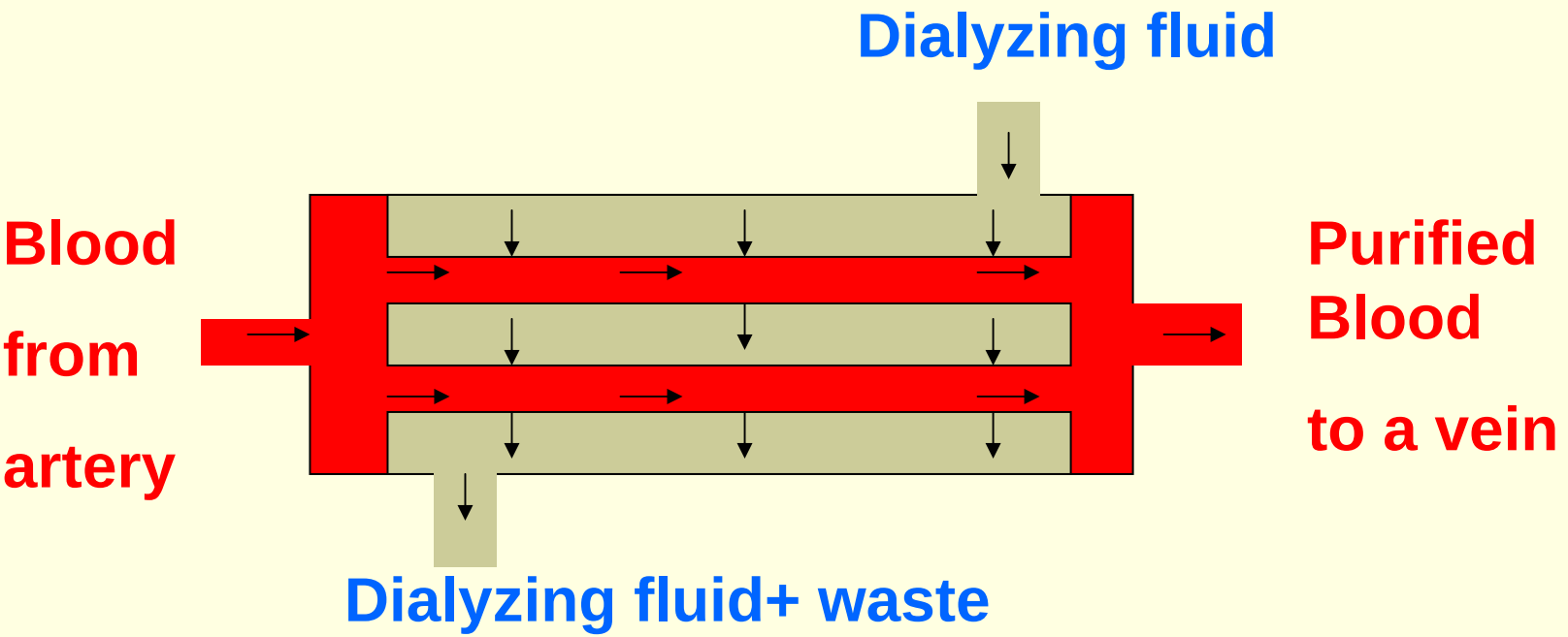
Assumptions

- w1, x2=1 are constants
- Perfect Mixing

Examples of non-continuous Processes

- Wood chip digester
- Plasma etcher
- Artificial Kidney

Artificial Kidney



- Remove water and waste metabolites from blood

Control Strategies

- Feedback
- Feedforward
- Feedforward + feedback
- others

Control Strategies

Feedback

- The control variable (CV) is measured
- Measured value is compared to set point
- The control action is computed based on the error
- Reduce the effect of disturbance irrespective of their sources
- Reduce the effects of changes in process on CV
- No corrective action is done before CV is changed

Control Strategies

Feedforward

- The disturbance variable (DV) is measured
- The correction action to remove the effect of the DV is calculated and implemented.
- Needs a good model of the system
- Limited. Not all disturbance variables can be measured
- Correction action is initiated before changes in CV are observed

Feedforward Control:

- Distinguishing feature: measure a disturbance variable

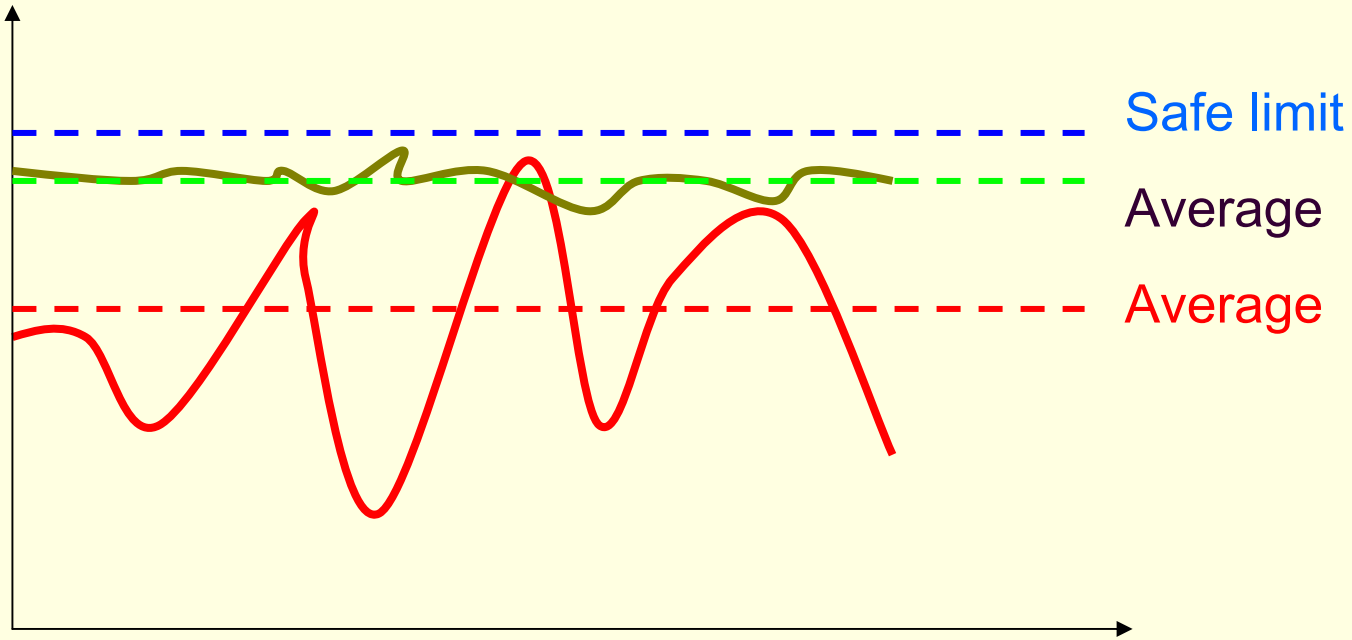
- **Advantage:**
  - Correct for disturbance before it upsets the process.
- **Disadvantage:**
  - Must be able to measure the disturbance.
  - No corrective action for unmeasured disturbances.
  - **Needs accurate model of the process**

Other Control Strategies

Feedforward+feedback

- Feedforward+feedback
  - Feedforward and feedback can be implemented at the same time
  - Practical approach
  - Feedforward remove the effect of measured disturbance and feedback remove the effect of un-measured disturbances
- Advanced control strategies

Economic Incentives for Advanced Process Control



Advance control can be used to reduce variability. This allows raising desired level closer to the safe limit

Summary