NAPEC

BASIC AUTOMATIC CONTROL

BY: MOHAMMED KOTB

Índex

The importance of process control

Process Control

The importance of process control

Process

The methods of changing or refining raw materials to create end products.

Process Control

The methods that are used to control process variables when manufacturing a product.

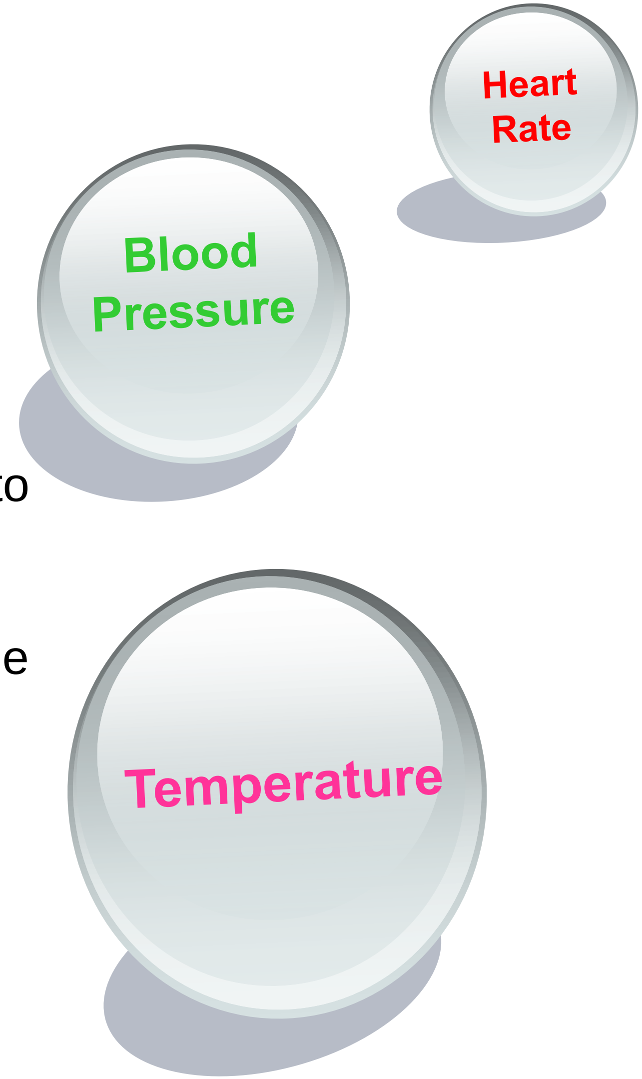
The importance of process control

Process Control

“Natural” process control

Defined as any operation that regulates some internal physical characteristic that is important to a living organism.

Examples of natural regulation in humans include body temperature, blood pressure, and heart rate.



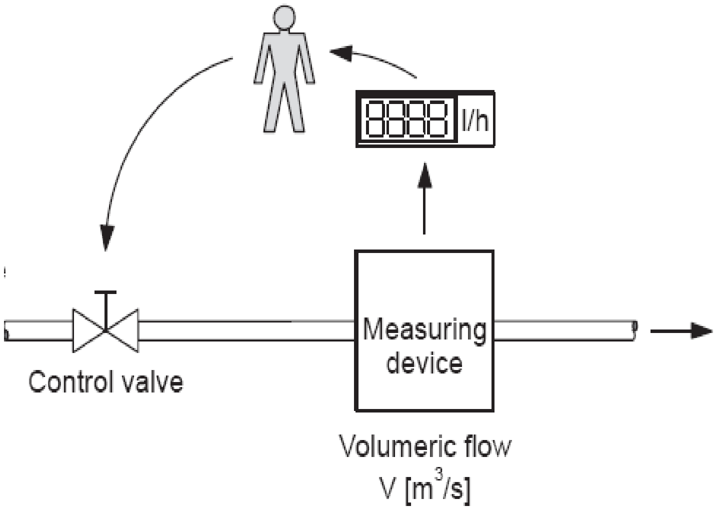
The importance of process control

Process Control

Automatic process control

This term came into wide use when people learned to adapt automatic regulatory procedures to manufacture products or process material more efficiently.

Such procedures are called automatic because no human (manual) intervention is required to regulate them.



The importance of process control

Process Control Importance

The importance of process control

Process Control Importance

Manufacturers control the production process for three reasons:

→Reduce variability

→ Increase efficiency

→ Ensure safety

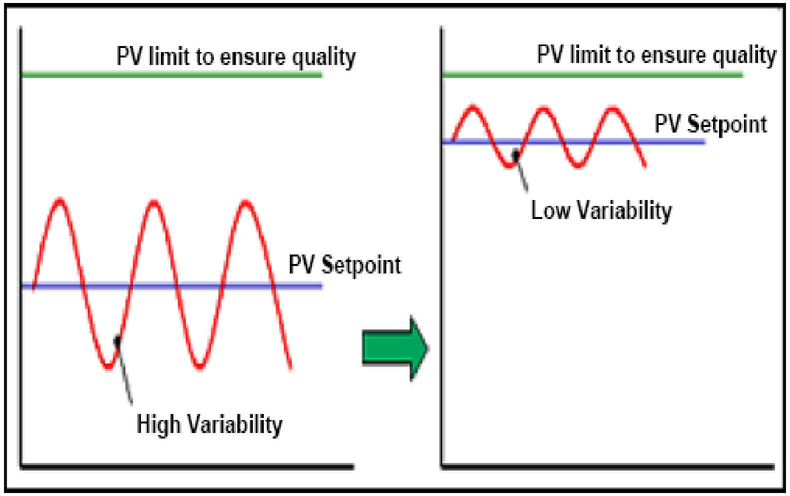
The importance of process control

Process Control Importance

Reduce Variability

Process control can reduce variability in the end product, which ensures a consistently high-quality product.

Manufacturers can also save money by reducing the need for product padding to meet required product specifications.

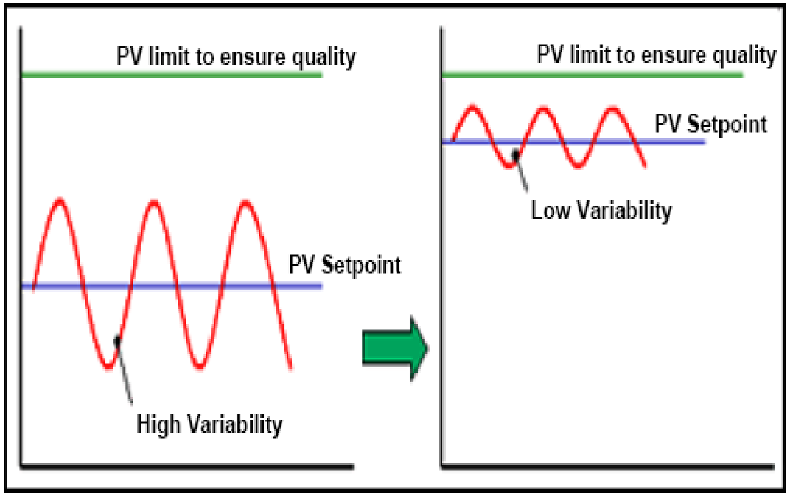


The importance of process control

Process Control Importance

Reduce Variability

Padding refers to the process of making a product of higher-quality than it needs to be to meet specifications.



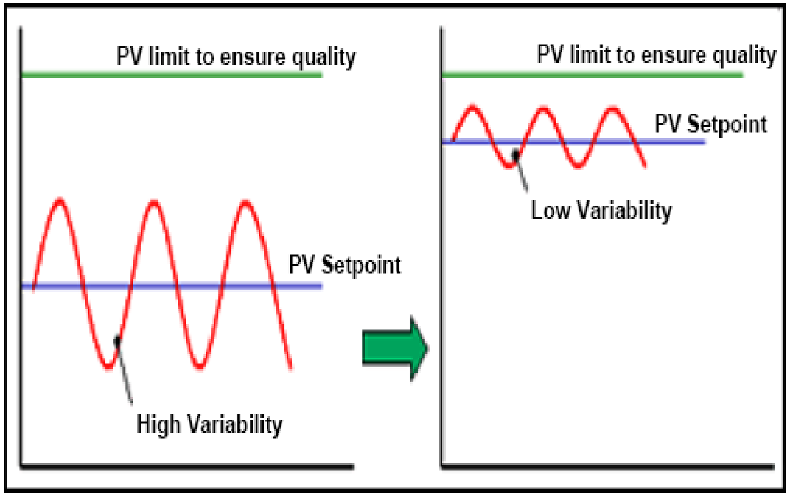
The importance of process control

Process Control Importance

Increase Efficiency

Some processes need to be maintained at a specific point to maximize efficiency.

Manufacturers save money by minimizing the resources required to produce the end product.



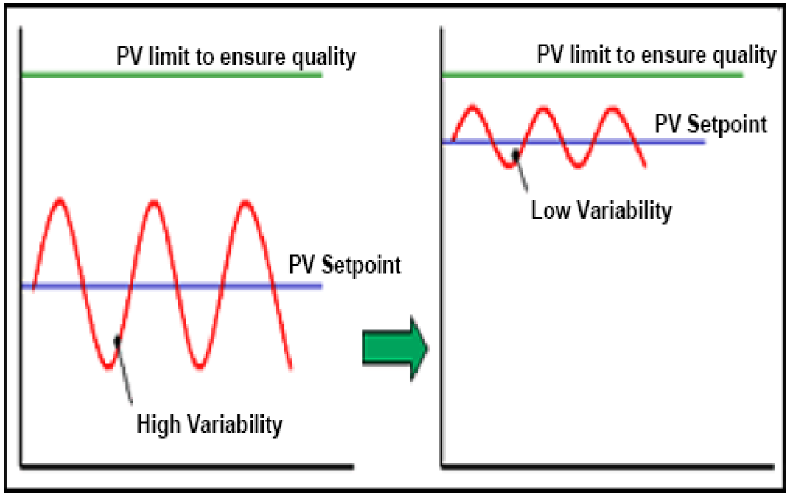
The importance of process control

Process Control Importance

Ensure Safety

A run-away process, such as an out-of-control nuclear or chemical reaction, may result if manufacturers do not maintain precise control of all of the process variables.

The consequences of a run-away process can be catastrophic.



Índex

- The importance of process control
- Control theory basics
- Components of control loops
- Controller algorithms and tuning
- Process control systems

Control Theory Basics

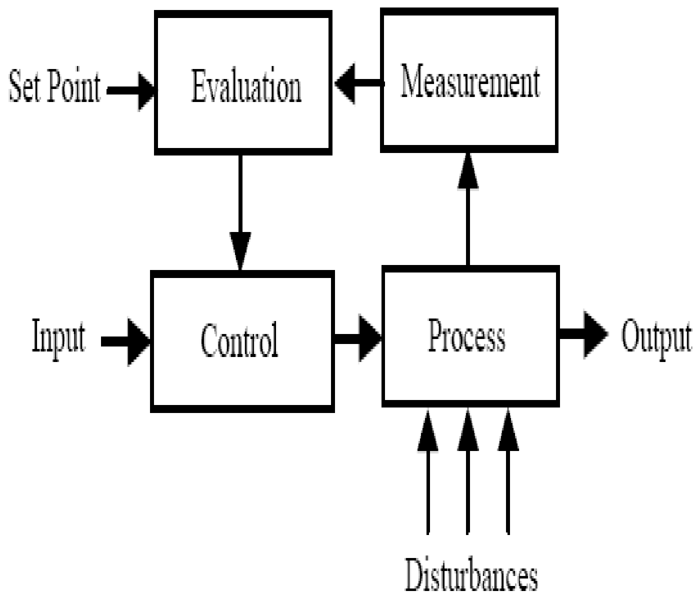
Process Control Elements

Control Theory Basics

Process Control Elements

Process control system consists of four essential elements:-

1. **Process**
2. **Measurement**
3. **Evaluation**
4. **Control**



Control Theory Basics

Process Control Elements

1. Process

The methods of changing or refining raw materials to create end products.

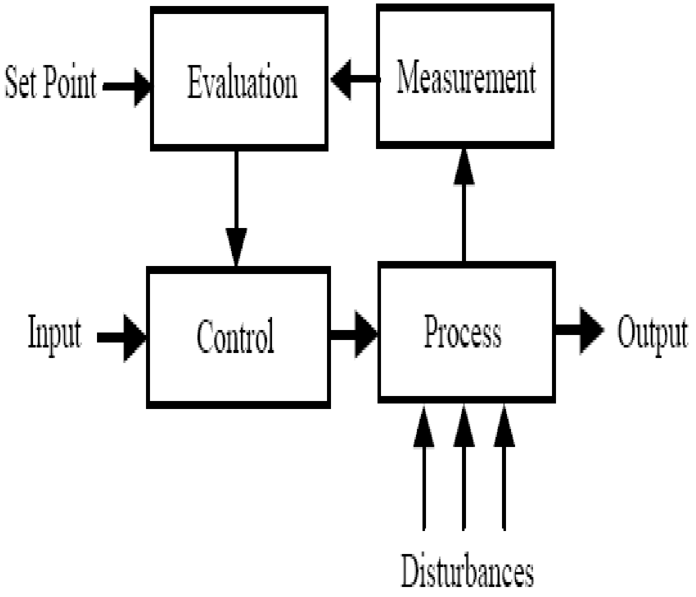
a process consists of an assembly of equipment and material that is related to some manufacturing operation.

Control Theory Basics

Process Control Elements

Process control system consists of four essential elements:-

1. **Process** ✓
2. **Measurement**
3. **Evaluation**
4. **Control**



Control Theory Basics

Process Control Elements

2. Measurement

Measurement refers to the conversion of the process variable into an analog or digital signal that can be used by the control system such as process control loop or sequence..

The device that performs the initial measurement is called a *sensor or instrument.*

Control Theory Basics

Process Control Elements

2. Measurement

Classification of instruments according to physical quantities :-

- →Pressure instruments
- →Flow instruments
- →level instruments
- →Temperature instruments
- →Analytical instruments
- →Miscellaneous instruments

Control Theory Basics

Process Control Elements

2. Measurement

Classification according to location will divide them into :-

→Field instruments

→Local Panel Instruments

→Central Control Panel Instruments.

Control Theory Basics

Process Control Elements

2. Measurement

Classification of instruments according to design will divide them into :-

→Pneumatic Instruments.

→Electronic Instruments (Analog)

→Electronic instruments (Digital)

→Hydraulic Instruments

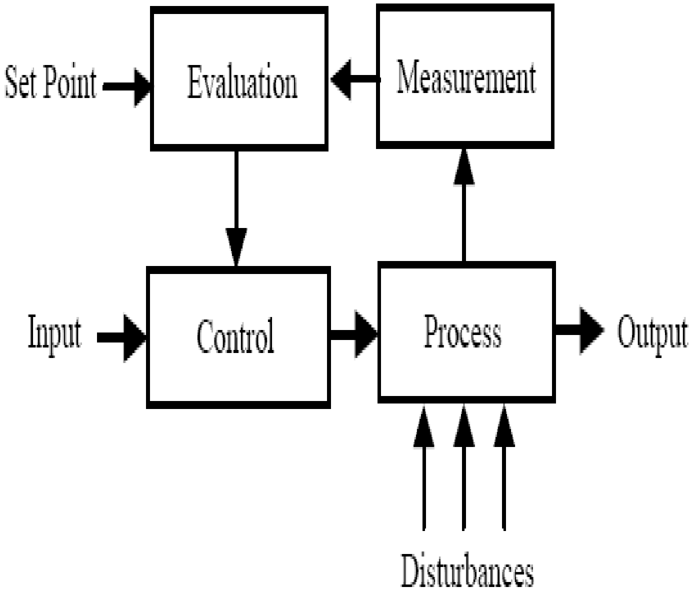
→Fluidic Instruments.

Control Theory Basics

Process Control Elements

Process control system consists of four essential elements:-

1. **Process**
2. **Measurement**
3. **Evaluation**
4. **Control**



Control Theory Basics

Process Control Elements

3. Evaluation

In this step the measurement value is examined, compared with the desired value or set point, and the amount of corrective action needed to maintain proper control is determined.

A device performs this evaluation called a controller.

Control Theory Basics

Process Control Elements

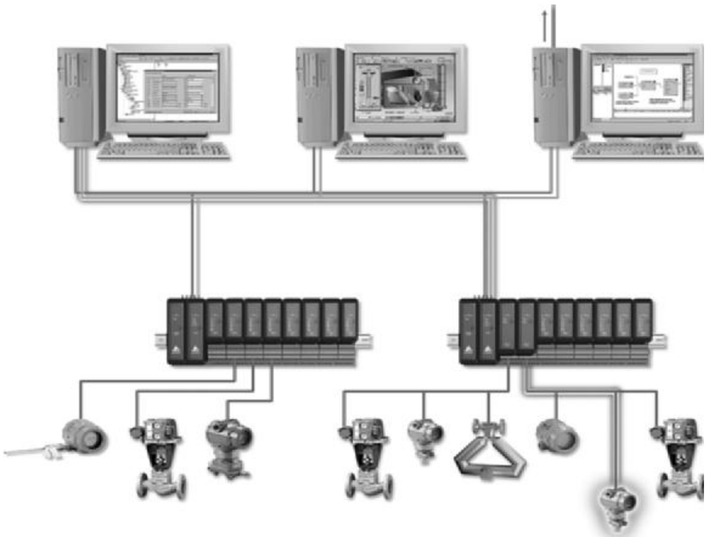
3. Evaluation

The controller can be

→**Pneumatic**

→**Electronic**

→**Mechanical device**



It can also be part of a computer control system, in which the control function is performed by software.

Control Theory Basics

Process Control Elements

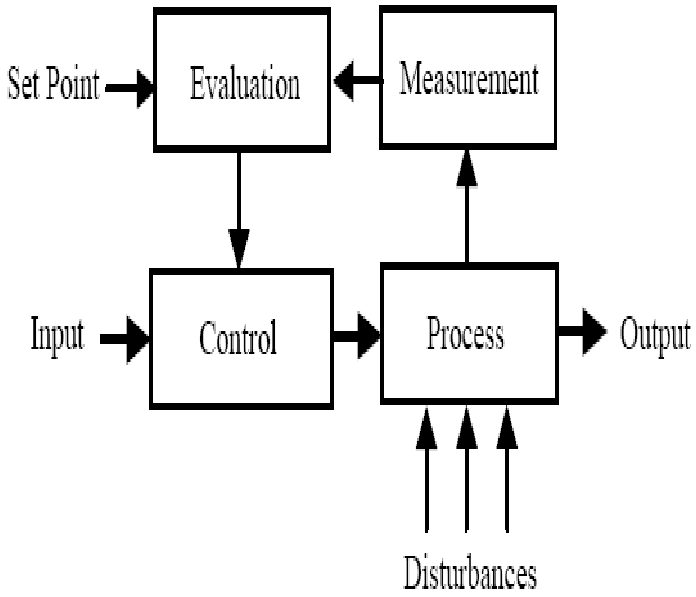
Process control system consists of four essential elements

→Process ✓

→Measurement ✓

→ Evaluation ✓

→ Control



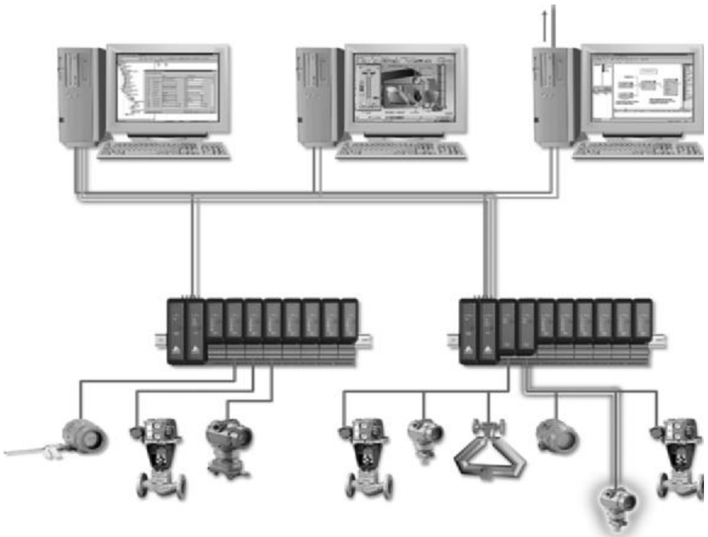
Control Theory Basics

Process Control Elements

4. Control

The control element in a control loop is the device that exerts a direct influence on the process.

This final control element accepts an input from the controller and transforms it into some proportional operation that is performed on the process



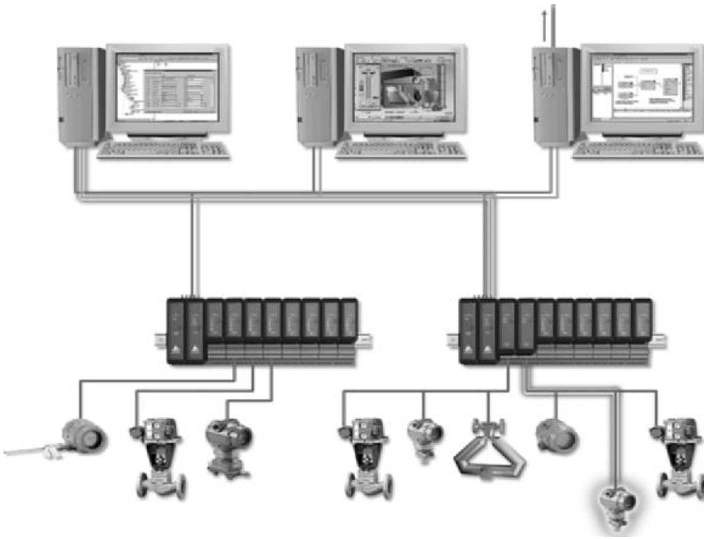
Control Theory Basics

Process Control Elements

4. Control

The final control element may be

- →Control valve
- →Electrical motors
- →Pumps
- →Dampers



Control Theory Basics

Process Control Terms

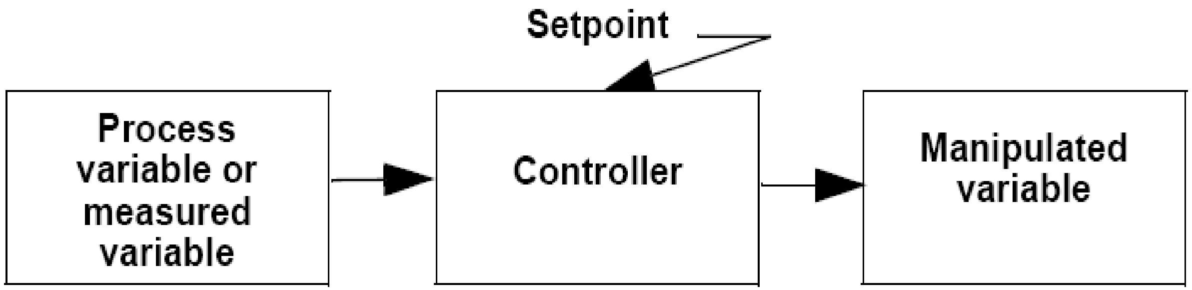
Control Theory Basics

Process Control Terms

Process Variable

The Process Variable is the condition of the process fluid that must be kept at the designated Set Point.

In most instances, the process variable is also the measured variable .

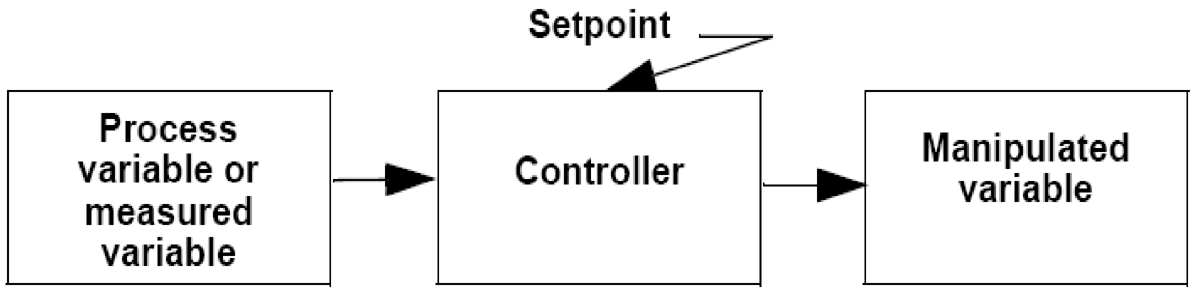


Control Theory Basics

Process Control Terms

Process Variable

Sometimes the measured variable is not the same as the process variable.
For example, a manufacturer may measure flow into and out of a storage tank to determine tank level. In this scenario, flow is the measured variable, and the process fluid level is the Process Variable.

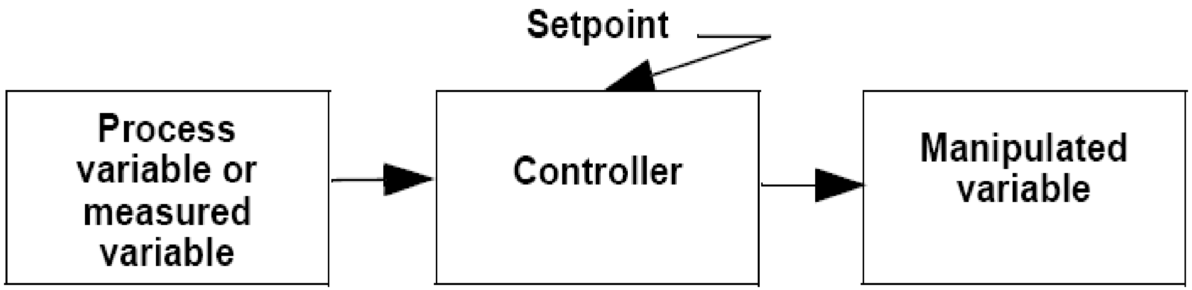


Control Theory Basics

Process Control Terms

Set Point

The set point is a value for a process variable that is desired to be maintained.

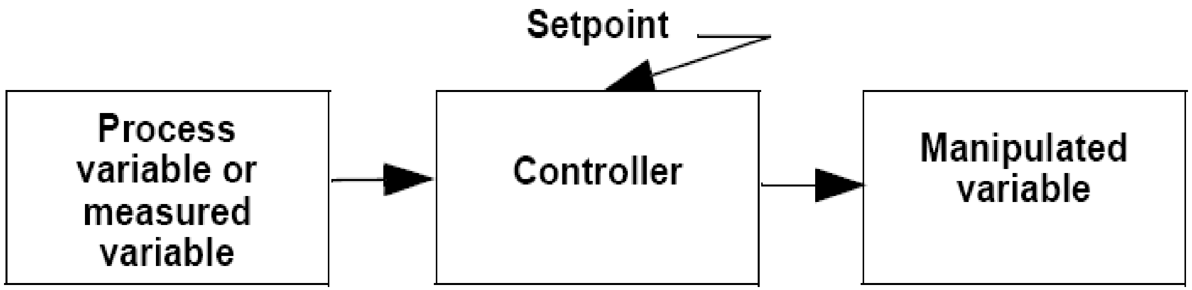


Control Theory Basics

Process Control Terms

Manipulated Variable

The factor that is changed to keep the measured variable at Set Point.

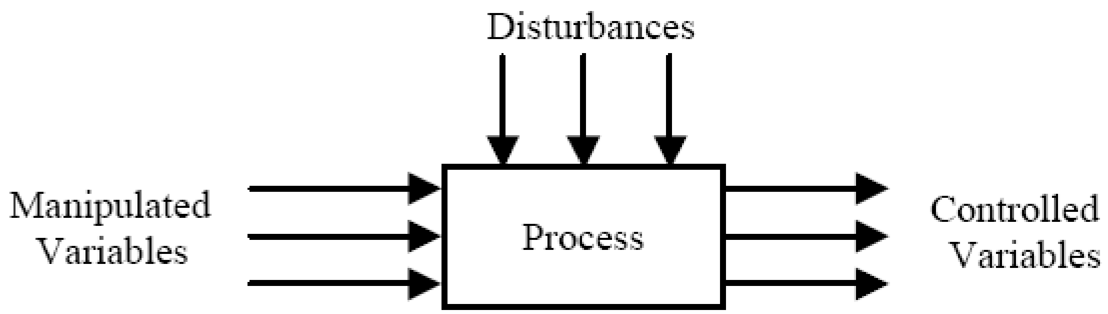


Control Theory Basics

Process Control Terms

LOAD DISTURBANCE

A load disturbance is an undesired change in one of the factors that can affect the process variable.

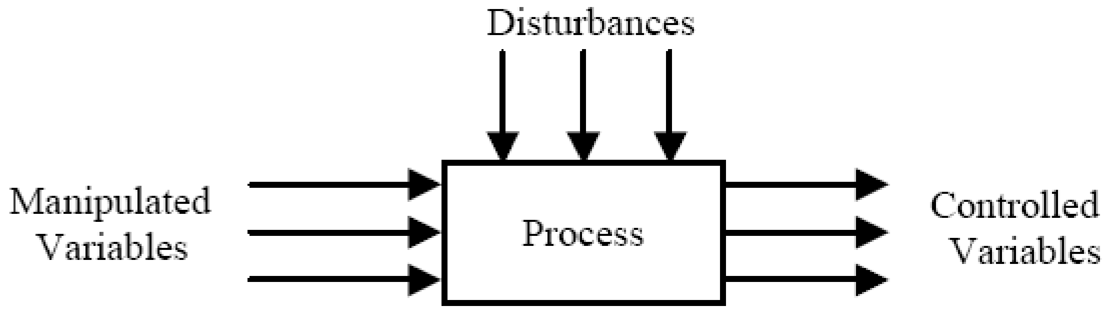


Control Theory Basics

Process Control Terms

LOAD DISTURBANCE

In the temperature control loop
adding cold process fluid to the vessel would be a load disturbance because it would lower the temperature of the process fluid.



Control Theory Basics

Process Control Terms

ERROR

Error is the difference between the measured variable and the Set point and can be either positive or negative.

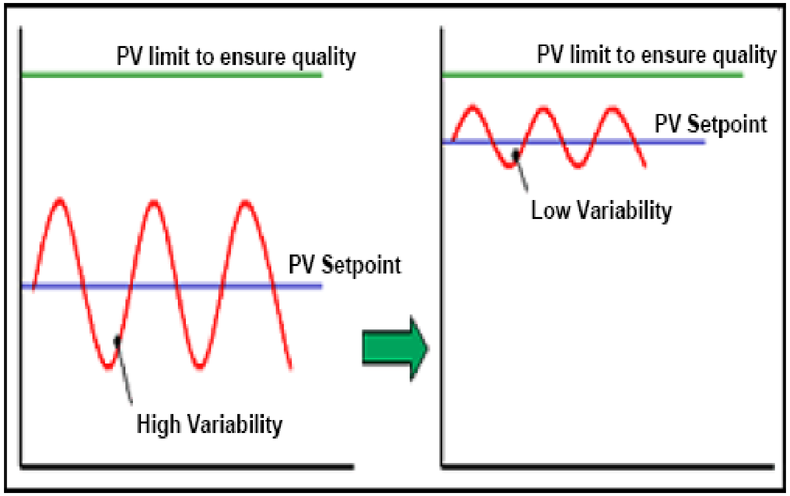
Control Theory Basics

Process Control Terms

ERROR

Magnitude

The magnitude of the error is simply the deviation between the values of the setpoint and the process variable.



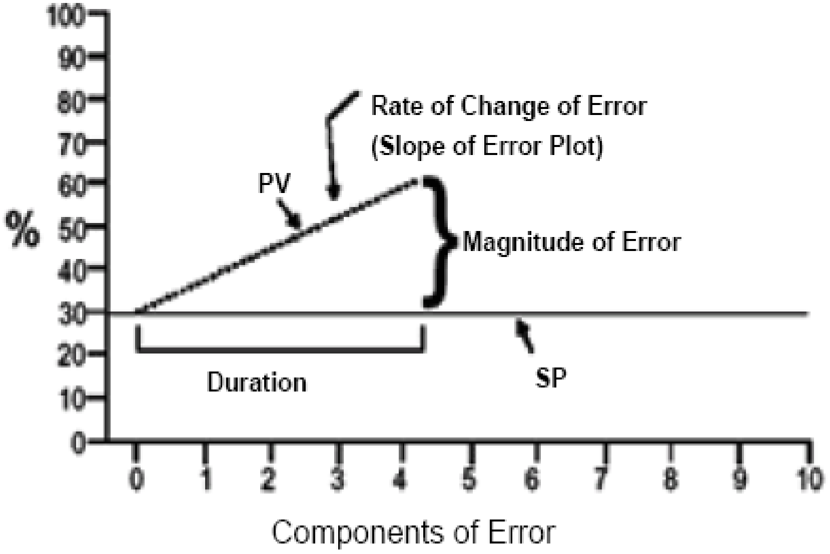
Control Theory Basics

Process Control Terms

ERROR

Duration Of Error

Duration refers to the length of time that an error condition has existed.



Control Theory Basics

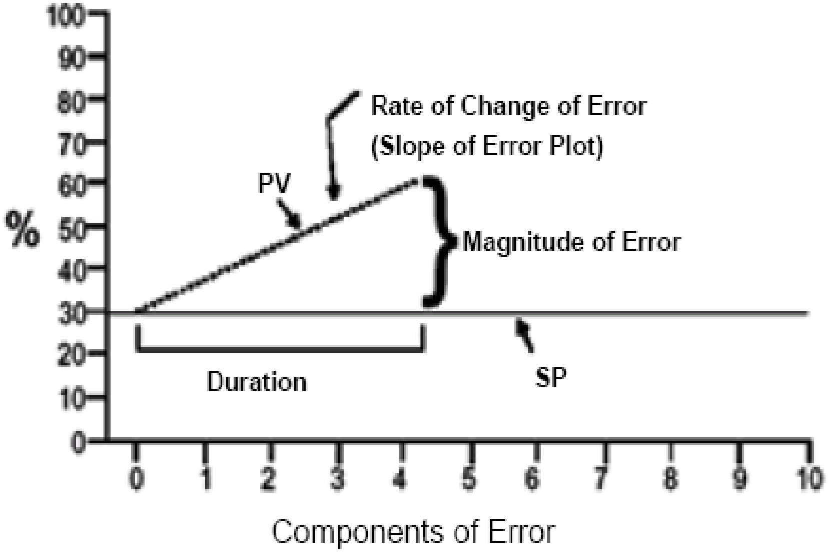
Process Control Terms

ERROR

Rate Of Change In Error

The magnitude of error at any point in time compared to the previous error

The rate of change is shown by the slope of the error plot.



Control Theory Basics

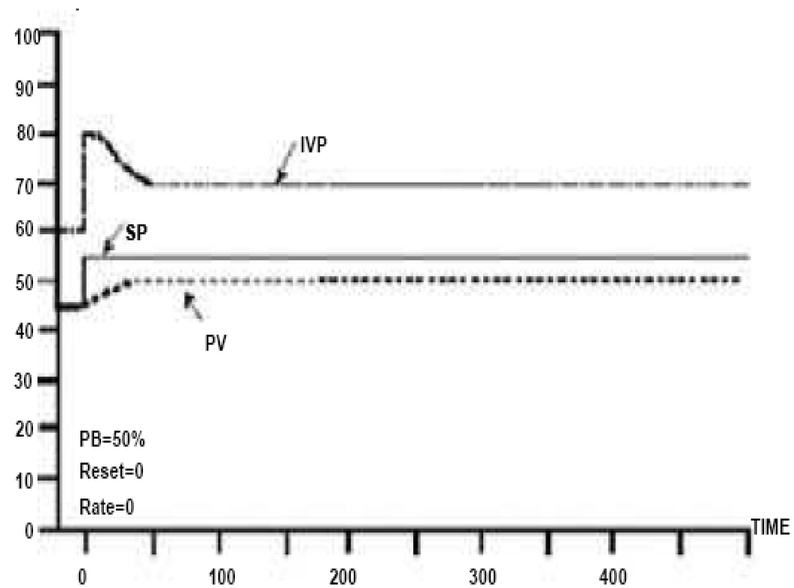
Process Control Terms

OFFSET

Offset is a sustained deviation of the process variable from the set point.

<u>Example</u>

In the temperature control loop .If the control system held the process fluid at 100.5 °C consistently, even though the set point is 100 °C, then an offset of 0.5 °C exists.

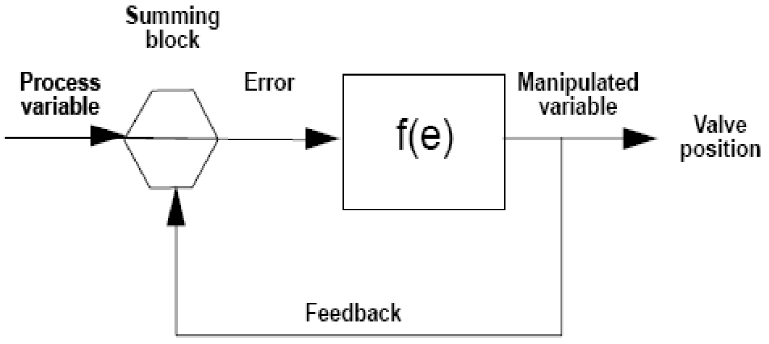


Control Theory Basics

Process Control Terms

CONTROL ALGORITHM

A control algorithm is a mathematical expression of a control function.



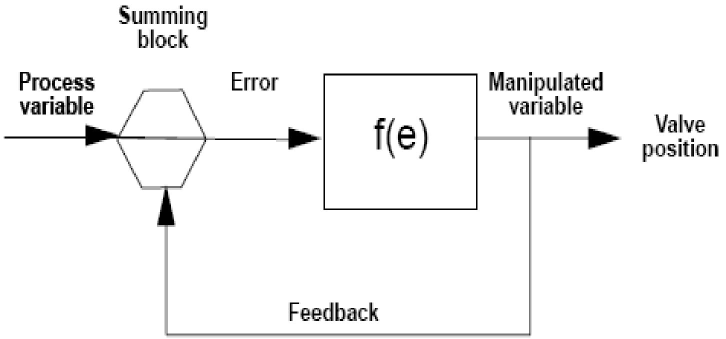
$$V = f(\pm e)$$

Control Theory Basics

Process Control Terms

CONTROL ALGORITHM

Control algorithms can be used to calculate



1. How far should the valve be opened or closed in response to a given change in set point

2. How long should the valve be held in the new position after the process variable moves back toward set point?

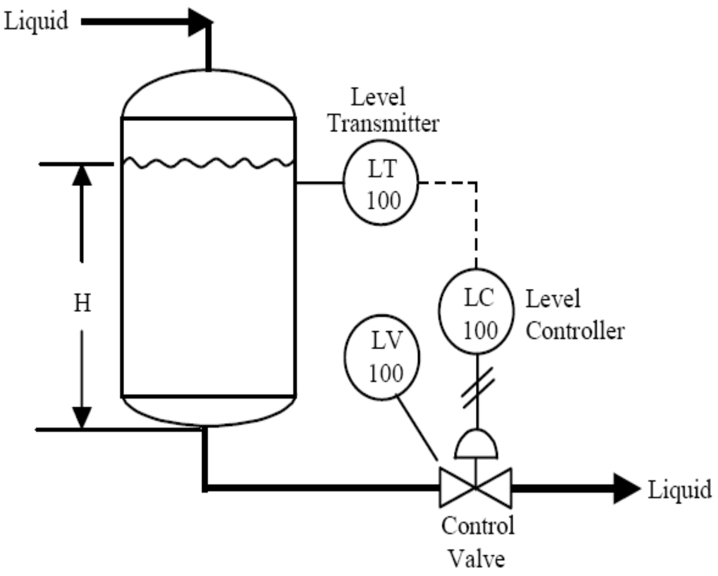
Control Theory Basics

Process Control Terms

CLOSED CONTROL LOOP

<u>Closed control loop exists where</u>

1. **Process Variable is measured.**
2. **Process Variable is Compared to a set point.**
3. **Corrective action is taken.**



Control Theory Basics

Process Control Terms

OPEN CONTROL LOOP

<u>Open control loop exists where</u>

1. **Process variable is <u>not</u> compared to a set point.**
2. **Corrective action is taken <u>regardless</u> process variable conditions.**

Control Theory Basics

Process Control Terms

OPEN CONTROL LOOP

Example

1. Cold water valve may be based on a pre-set time interval, regardless of the actual temperature of the process fluid.

2. An irrigation sprinkler system, programmed to turn on at set times regardless soil moisture content.

3. Air compressor moisture drain valves.

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Components Of Control Loops

Control Loops Elements

Components Of Control Loops

Control Loops Elements

PRIMARY ELEMENTS/SENSORS

Primary elements are devices that cause some change in their property with changes in process fluid conditions that can then be measured.

Components Of Control Loops

Control Loops Elements

PRIMARY ELEMENTS/SENSORS

- Pressure Sensing Diaphragms, Strain Gauges, Capacitance Cells
- Resistance Temperature Detectors (RTDs)
- Thermocouples
- Orifice Plates
- Pitot Tubes
- Venturi Tubes
- Magnetic Flow Tubes
- Coriolis Flow Tubes
- Radar Emitters And Receivers
- Ultrasonic Emitters And Receivers
- Annubar Flow Elements
- Vortex Sheddar

Components Of Control Loops

Control Loops Elements

TRANSDUCERS

A transducer is a device that translates a mechanical signal into an electrical signal.

For example, inside a capacitance pressure device, a transducer converts changes in pressure into a proportional change in capacitance.

Components Of Control Loops

Control Loops Elements

CONVERTERS

A converter is a device that converts one type of signal into another type of signal.

For example, a converter may convert current into voltage or an analog signal into a digital signal.

In process control, a converter used to convert a 4–20 mA current signal into a 3–15 psig pneumatic signal (commonly used by valve actuators) is called a current-to-pressure converter.

Components Of Control Loops

Control Loops Elements

TRANSMITTERS

A transmitter is a device that converts a reading from a sensor or transducer into a standard signal and transmits that signal to a monitor or controller.

Transmitter types include:

1. Pressure transmitters
2. Flow transmitters
3. Temperature transmitters
4. Level transmitters
5. Analytic (O2 [oxygen], CO [carbon monoxide], and pH) transmitters

Components Of Control Loops

Control Loops Elements

SIGNALS

There are three kinds of signals that exist for the process industry to transmit the process variable measurement from the instrument to a centralized control system.

1. Pneumatic signal
2. Analog signal
3. Digital signal

Components Of Control Loops

Control Loops Elements

Pneumatic Signals

Pneumatic signals are signals produced by changing the air pressure in a signal pipe in proportion to the measured change in a process variable.

The common industry standard pneumatic signal range is 3–15 psig.

3 psig	corresponds to the lower range value (LRV)
15 psig	corresponds to the upper range value (URV)

Components Of Control Loops

Control Loops Elements

Pneumatic Signals

1. Pneumatic signaling is still common.

2. Electronic instruments and the lower costs involved in running electrical signal wire has made pneumatic signal technology less attractive.

Components Of Control Loops

Control Loops Elements

Analog Signals

The most common standard electrical signal is the 4–20 mA current signal. With this signal, a transmitter sends a small current through a set of wires.

The common industry standard Analog signal range is 4–20 mA

4 mA	corresponds to the lower range value (LRV)
20 mA	corresponds to the upper range value (URV)

Components Of Control Loops

Control Loops Elements

Analog Signals

1. Other common standard electrical signals range is 0–20 mA

2. Other common standard electrical signals include the 1–5 V (volts) signal and the pulse output.

Components Of Control Loops

Control Loops Elements

Digital Signals

Digital signals are discrete levels or values that are combined in specific ways to represent process variables and also carry other information, such as diagnostic information.

Digital signals are the most recent addition to process control signal technology.

Components Of Control Loops

Control Loops Elements

Digital Signals

Protocol

Protocol is the methodology used to combine the digital signals

Manufacturers may use either

1. Open Protocols
2. Proprietary Protocols

Components Of Control Loops

Control Loops Elements

Digital Signals

Open Protocols

Open protocols are those that anyone who is developing a control device can use.

Open digital protocol includes

1. HART® protocol.*
2. FOUNDATION™ Fieldbus protocol.
3. Profibus protocol.
4. DeviceNet protocol.
5. Modbus® protocol.

* (highway addressable remote transducer)

Components Of Control Loops

Control Loops Elements

Digital Signals

Proprietary Protocols

Proprietary protocols are owned by specific companies and may be used only with their permission

Components Of Control Loops

Control Loops Elements

INDICATORS

An indicator is a human-readable device that displays information about the process at the measurement point

Some indicators simply display the measured variable such as a pressure or temperature gauge

Others have control buttons that enable operators to change settings in the field.

Components Of Control Loops

Control Loops Elements

RECORDERS

A recorder is a device that records the output of a measurement devices.

Many process manufacturers are required by law to provide a process history to regulatory agencies.

By recording and comparing those readings over time with the results of the process, the process can be improved.

Components Of Control Loops

Control Loops Elements

RECORDERS

A recorder is a device that records the output of a measurement devices.

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Components Of Control Loops

Control Loops Elements

CONTROLLER

A controller is a device that receives data from a measurement instrument, compares that data to a programmed set point, and signals a control element.

Local controllers are usually one of the three types:

1. Pneumatic
2. Electronic
3. Programmable.

Components Of Control Loops

Control Loops Elements

CONTROLLER

Controllers also commonly reside in a digital control system such as.

1. **Programmable Logic Controllers (PLC)**

2. **Distributed Control Systems (DCS)**

Components Of Control Loops

Control Loops Elements

CONTROLLER

1. Programmable Logic Controllers (PLC)

PLCs are usually computers connected to a set of input/output (I/O) devices. The computers are programmed to respond to inputs by sending outputs to maintain all processes at set point.

2. Distributed Control Systems (DCS)

DCSs are controllers that, in addition to performing control functions, provide readings of the status of the process, maintain databases and advanced man-machine-interface.

Components Of Control Loops

Control Loops Elements

FINAL CONTROL ELEMENTS

Final control element is the part of the control system that acts to physically change the manipulated variable.

Components Of Control Loops

Control Loops Elements

ACTUATORS

An actuator is the part of a final control device that causes a physical change in the final control device when signaled to do so.

The most common example of an actuator is a valve actuator, which opens or closes a valve in response to control signals from a controller.

Actuators are often powered pneumatically, hydraulically, or electrically.

Índex

Controller Algorithms And Tuning

Types Of Controllers

Controller Algorithms And Tuning

Types Of Controllers

Four types of control are:

1. **MANUAL CONTROL**
2. **DISCRETE CONTROL**
3. **MULTISTEP CONTROL**
4. **CONTINUOUS CONTROL**

Controller Algorithms And Tuning

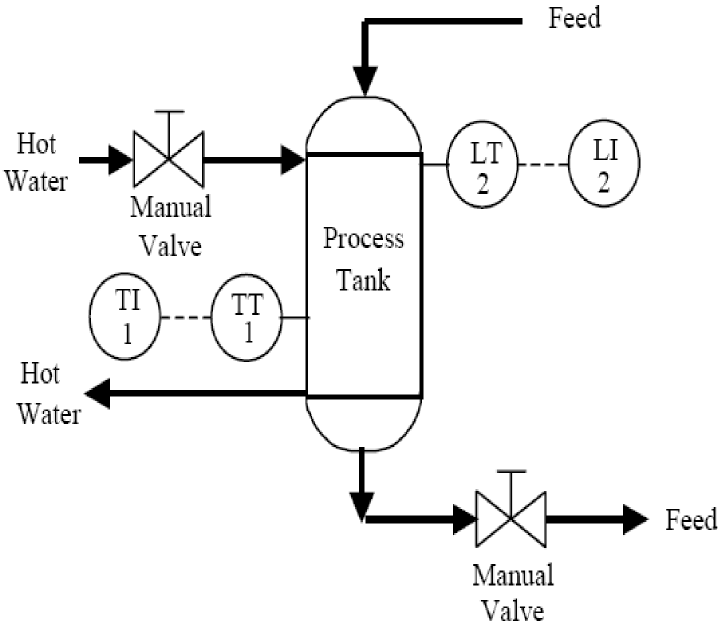
Types Of Controllers

MANUAL CONTROL

Suppose a process operator has the task of holding the temperature T, near the desired temperature, Td

He would manually adjust the hot water inlet valve (HV-1) to maintain the temperature

and occasionally adjust the outlet valve (HV-2) to maintain the correct level in the tank.



Controller Algorithms And Tuning

Types Of Controllers

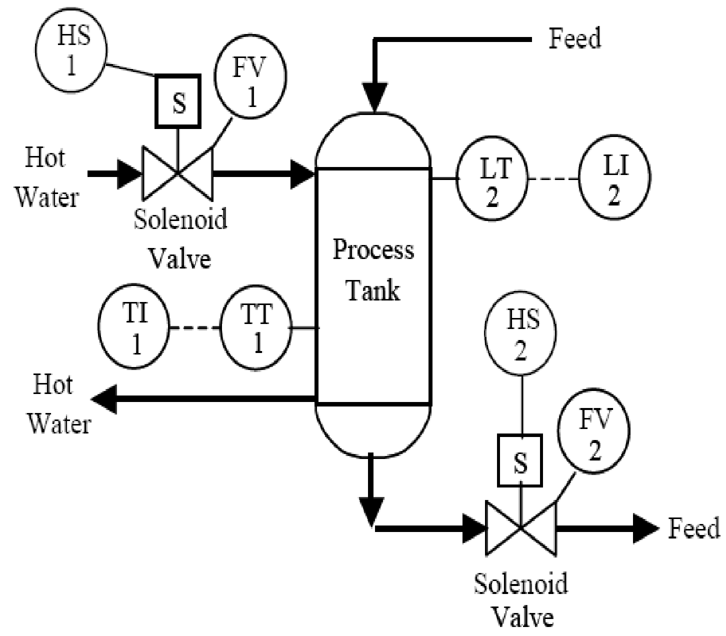
DISCRETE CONTROL

Suppose electrically operated solenoid valves are installed in place of the manual valves to make the operator's work easier.

The valves can assume two states, either fully open (on) or fully closed (off).

This type of control is called

Two-position control Or On/Off control.

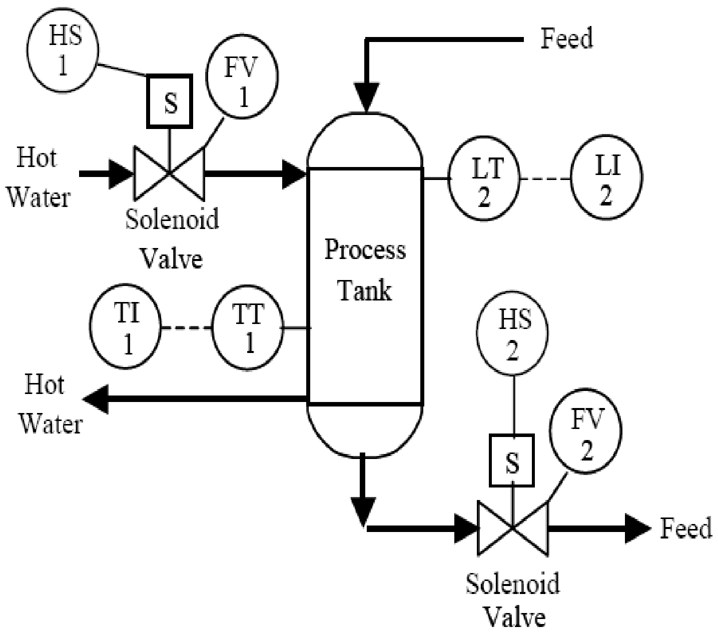


Controller Algorithms And Tuning

Types Of Controllers

DISCRETE CONTROL

Two hand switches (HS-1 and HS-2) can be installed so the solenoid valves can be operated from a common location either Manual or Automatic.



Controller Algorithms And Tuning

Types Of Controllers

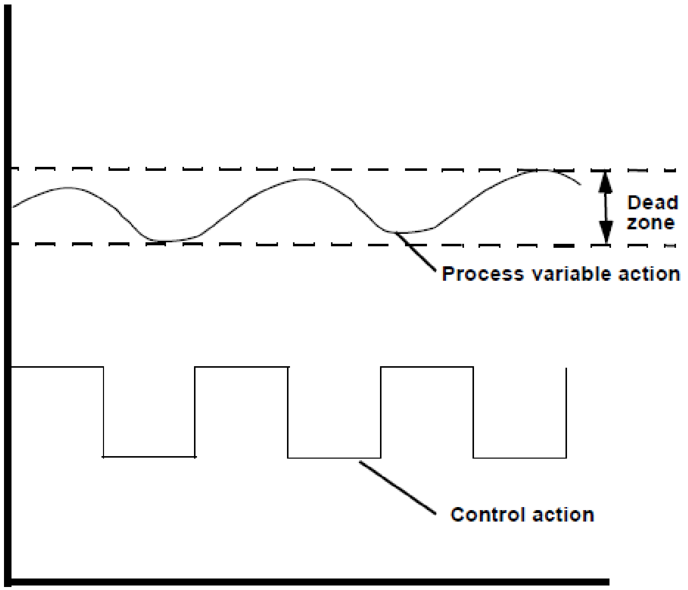
DISCRETE CONTROL

Controllers that have only two positions: on and off.

This type of control doesn't actually hold the variable at set point

But

It keeps the variable within proximity of set point in what is known as a dead zone



Controller Algorithms And Tuning

Types Of Controllers

DISCRETE CONTROL

This on/off type of control can be expressed mathematically as follows:

$$e = PV - SP$$

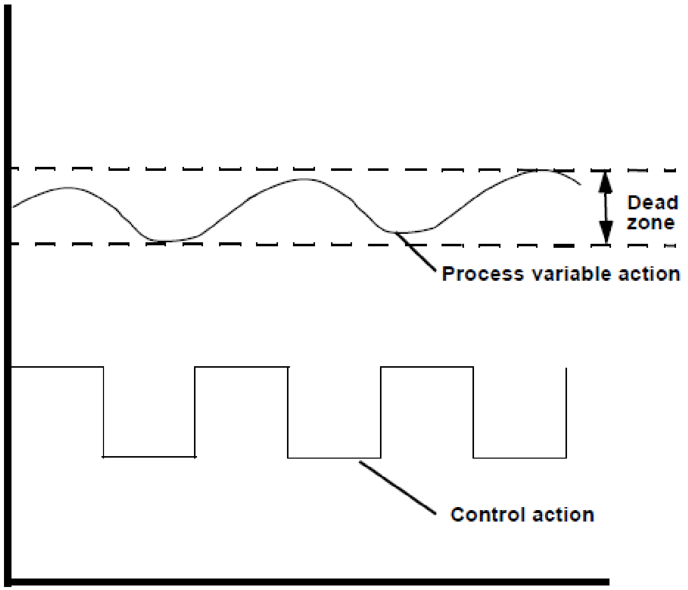
Where

e = the error

SP = the set point

PV = the process variable

The valve is open when (e) is positive (+)
The valve is closed when (e) is negative (–).



Controller Algorithms And Tuning

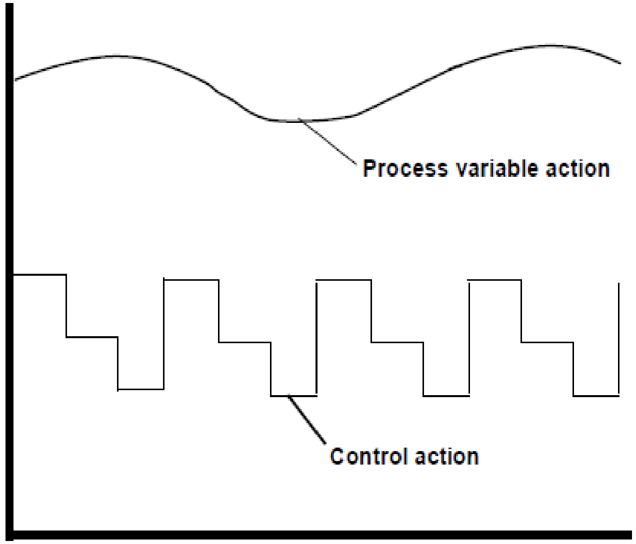
Types Of Controllers

MULTISTEP CONTROL

Controllers that have at least one other possible position in addition to on and off.

Operate similarly to discrete controllers, but as set point is approached, the multistep controller takes intermediate steps.

The oscillation around set point can be less dramatic.



Controller Algorithms And Tuning

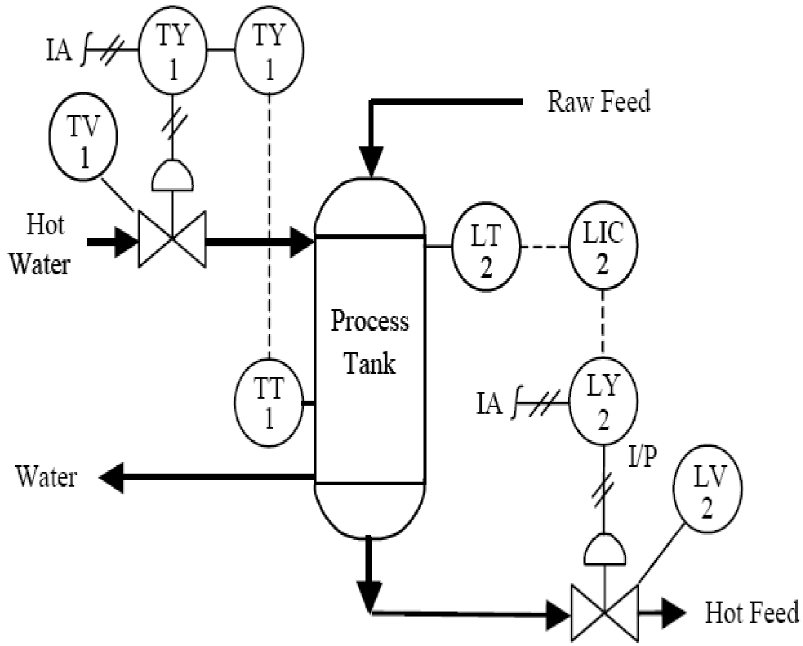
Types Of Controllers

CONTINUOUS CONTROL

Controllers automatically compare the value of the PV to the SP.

If there is an error,

The controller adjusts its output according to the Tuning Parameters that have been set in the controller.



Controller Algorithms And Tuning

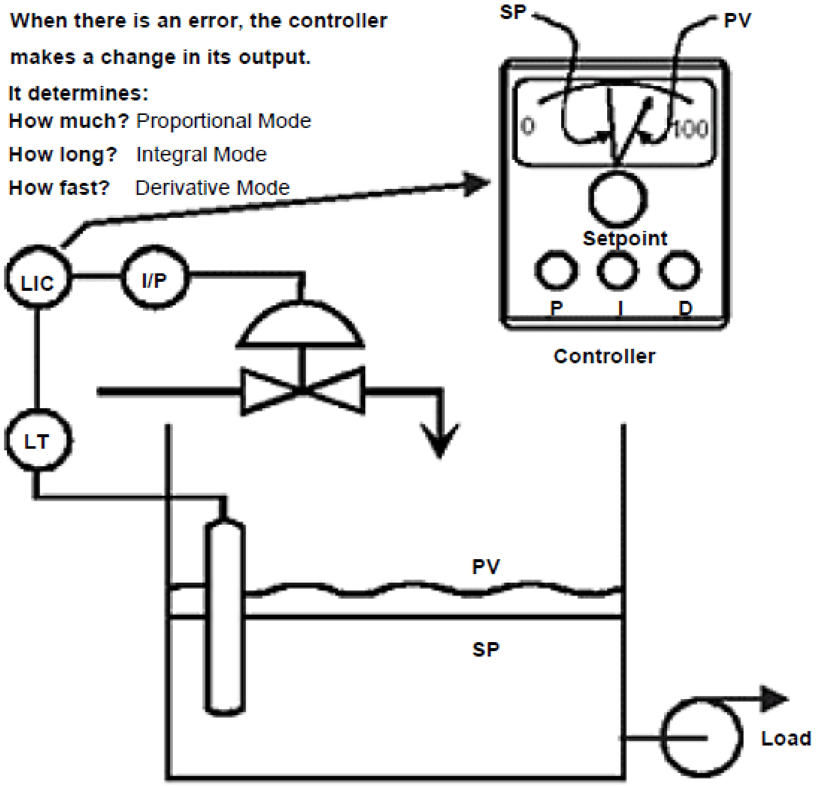
Types Of Controllers

CONTINUOUS CONTROL

The Tuning Parameters essentially determine:

How much correction should be made?

The magnitude of the correction(change in controller output) is determined by the proportional mode of the controller.



Controller Algorithms And Tuning

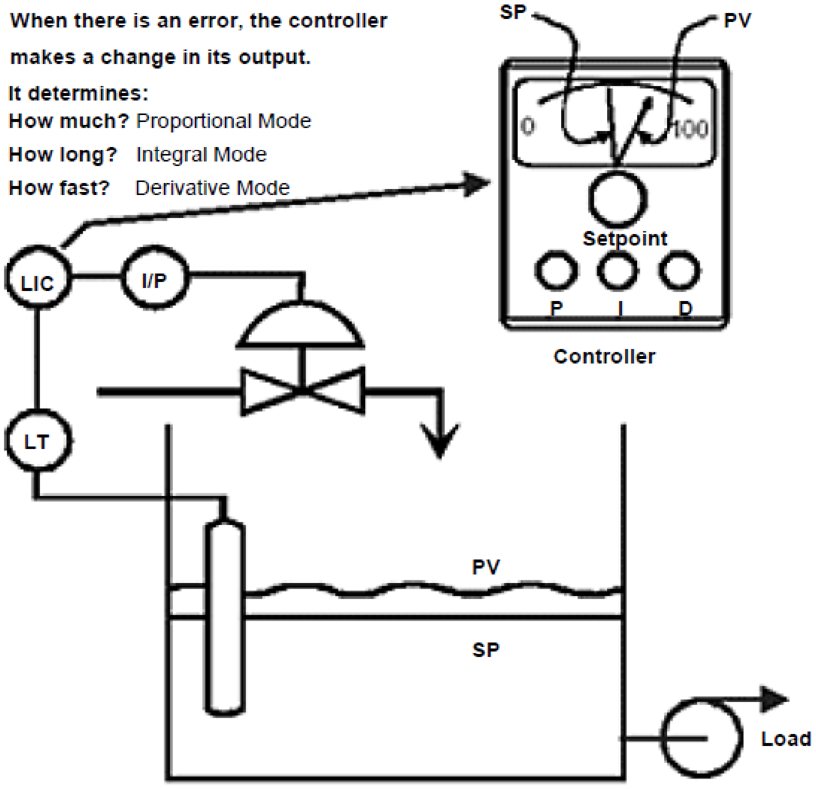
Types Of Controllers

CONTINUOUS CONTROL

The Tuning Parameters essentially determine:

How long should the correction be applied?

The duration of the adjustment to the controller output is determined by the integral mode of the controller



Controller Algorithms And Tuning

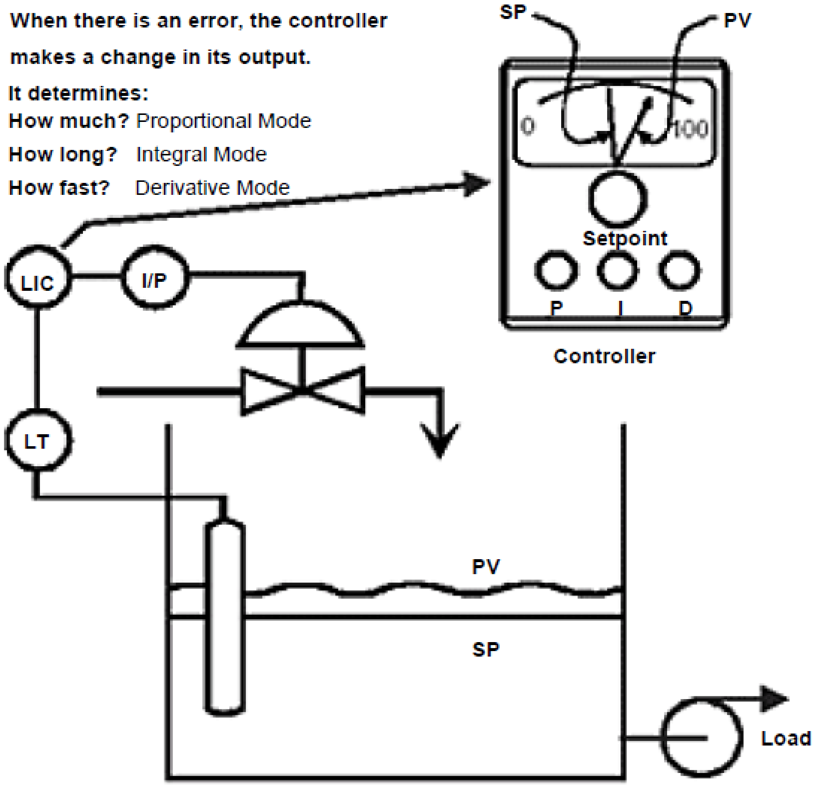
Types Of Controllers

CONTINUOUS CONTROL

The Tuning Parameters essentially determine:

How fast should the correction be applied?

The speed at which a correction is made is determined by the derivative mode of the controller.



Controller Algorithms And Tuning

Tuning Parameters

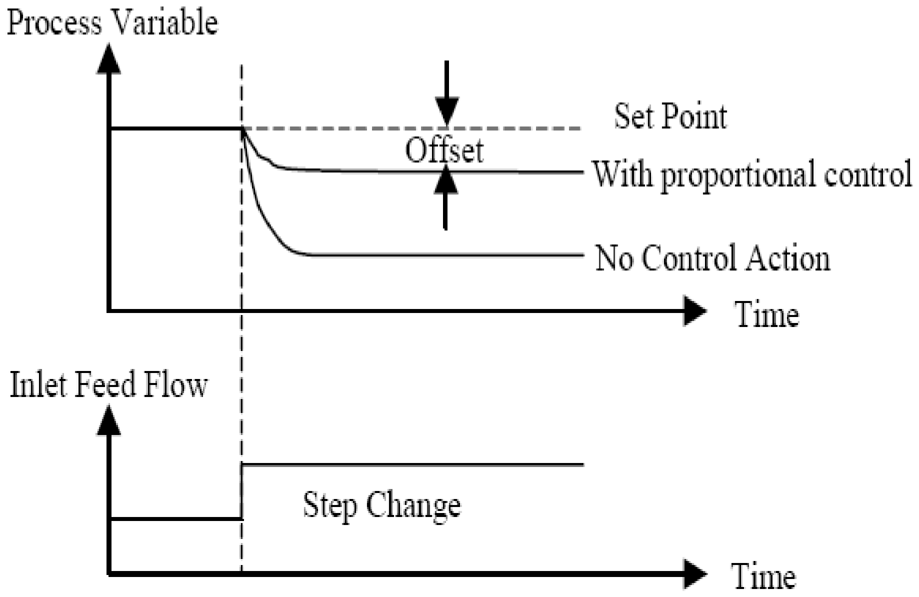
Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

Before proportional control can be implemented

The solenoid valves must be change to adjustable control valves.



Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

Proportional control can be described mathematically as follows:

$$V = K_c e + m$$

Where

V = is the control valve position

K_c = is the adjustable proportional gain of a typical process controller

m = is a constant, which is the position of the control valve when the system error (e) is zero.

Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

Proportional Gain

Gain is defined as

The change in output divided by the change in input.

Examples:

Change in Input to Controller - 10%
Change in Controller Output - 5%
Gain = 5% / 10% = 0.5

Controller Algorithms And Tuning

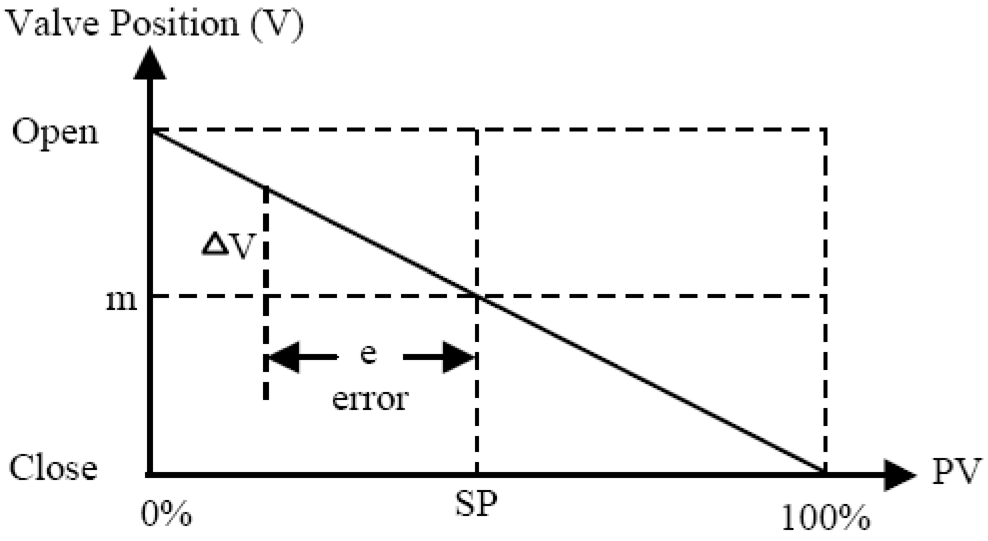
Tuning Parameters

Proportional Control

Proportional Gain

$$V = K_c e + m$$

a) Gain of one, K_c **= 1**



Controller Algorithms And Tuning

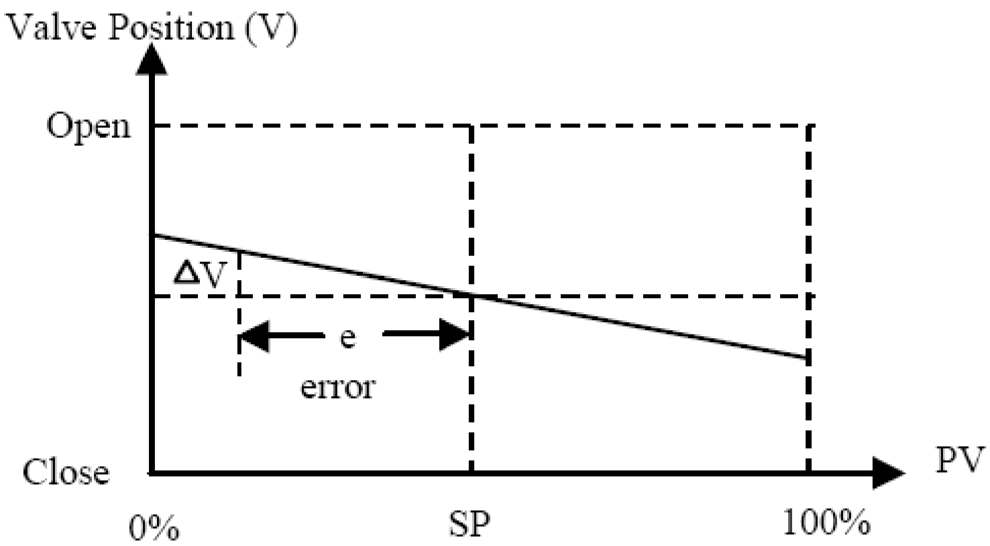
Tuning Parameters

Proportional Control

Proportional Gain

$$V = K_c e + m$$

b) Low Gain, K_c **< 1**



Controller Algorithms And Tuning

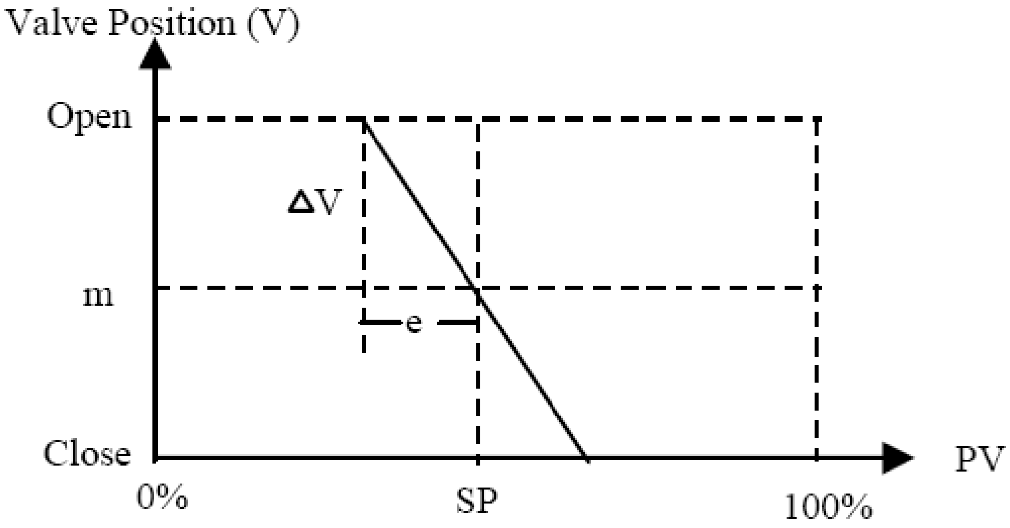
Tuning Parameters

Proportional Control

Proportional Gain

$$V = K_c e + m$$

c) High Gain, K_c **> 1**



Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

Proportional Band

Percentage of change of the controller input span that cause a 100% change in controller output

$$PB = \frac{1}{K_c} \times 100 \qquad K_c = \frac{1}{PB} \times 100$$

Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

Proportional Band

Percentage of change of the controller input span that cause a 100% change in controller output

$$PB = \frac{1}{K_c} x 100$$

$$K_c = \frac{1}{PB} x 100$$

Controller Algorithms And Tuning

Tuning Parameters

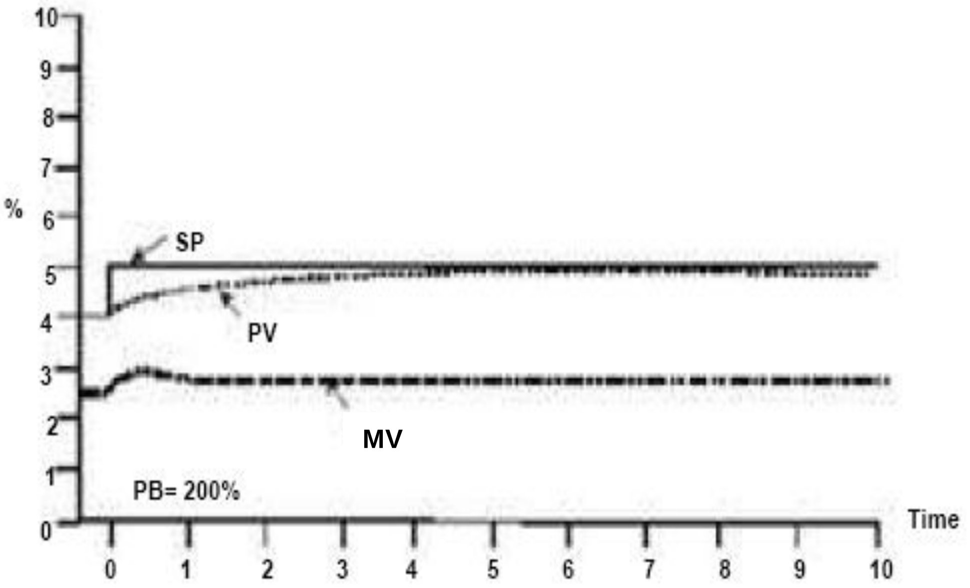
Proportional Control

Low Gain Example

The proportional band is high (gain is low).

The loop is very stable

Notice that an error remains between SP and PV.



Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

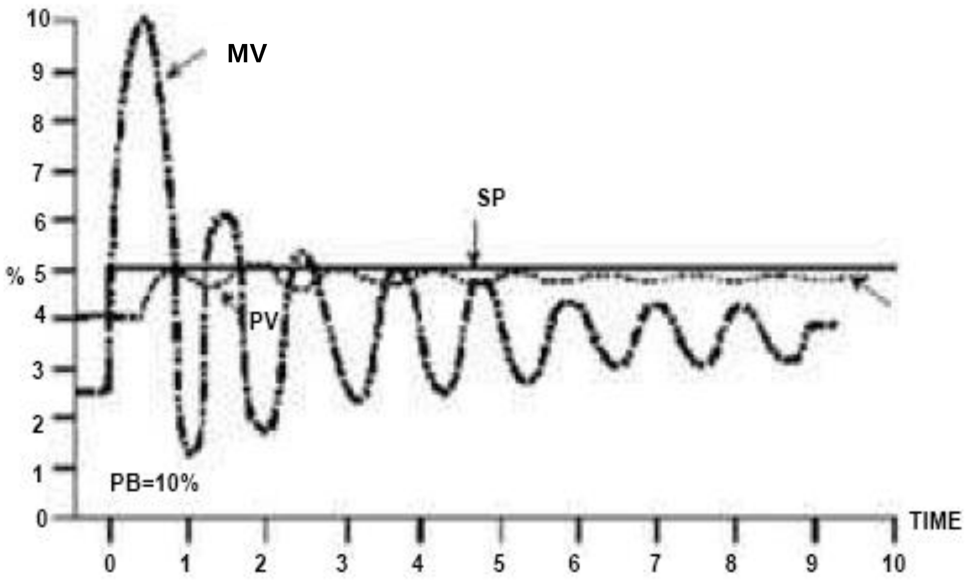
High Gain Example

The proportional band is small (gain is high)

The loop is very unstable.

Offset will be small.

Notice that the process variable is still not on set point.



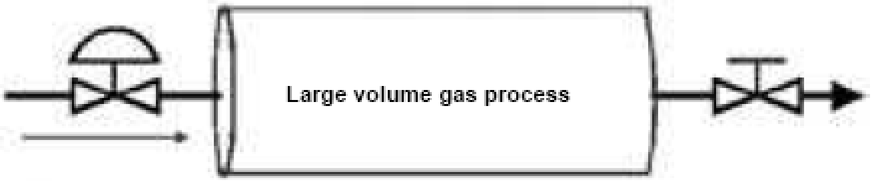
Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

Fast Process May Require Less Gain To Achieve Stability

Slow Process May Require Higher Gain To Achieve Responsiveness



Controller Algorithms And Tuning

Tuning Parameters

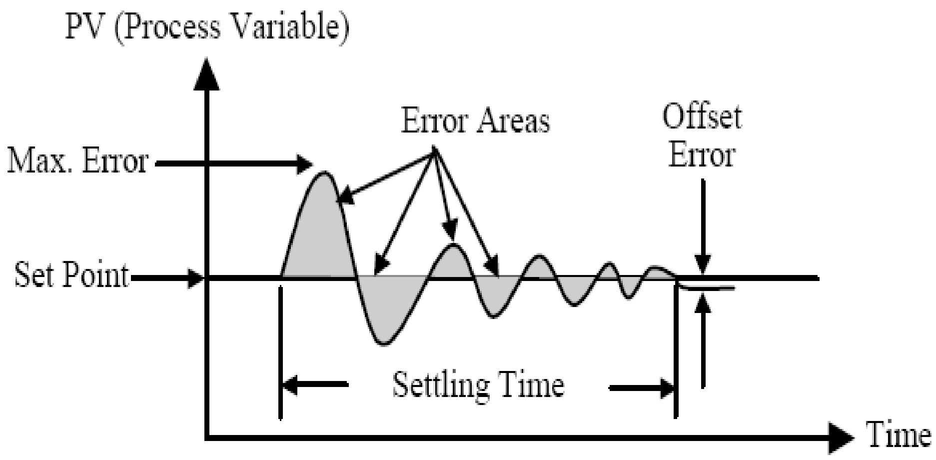
Proportional Control

1. Proportional Mode Responds only to a change in error

2. Proportional mode alone will not return the PV to SP.

Advantages – Simple

Disadvantages - Offset Error



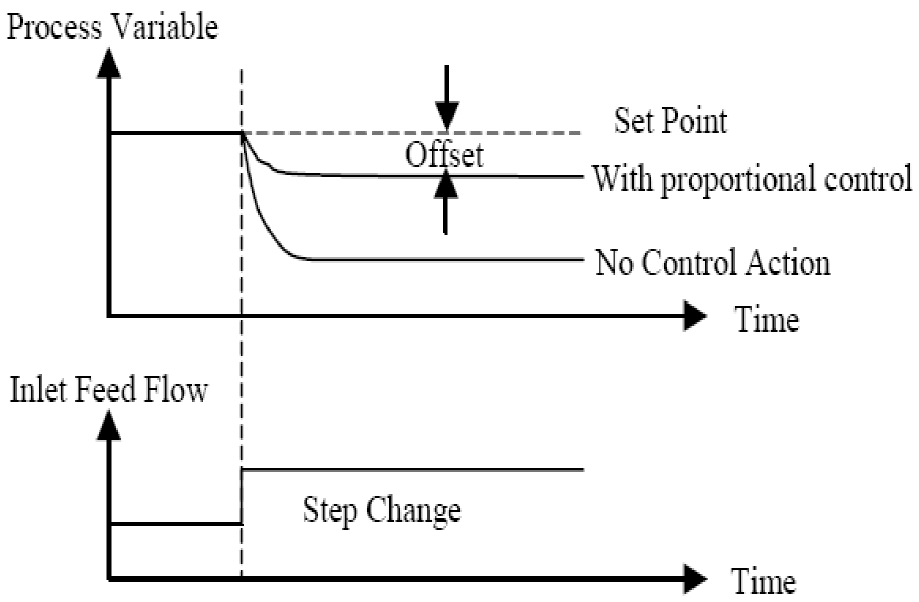
Controller Algorithms And Tuning

Tuning Parameters

Proportional Control

One way to cope with the offset problem is by manually adjusting the m term.(manual reset)

$$V = K_c e + m$$

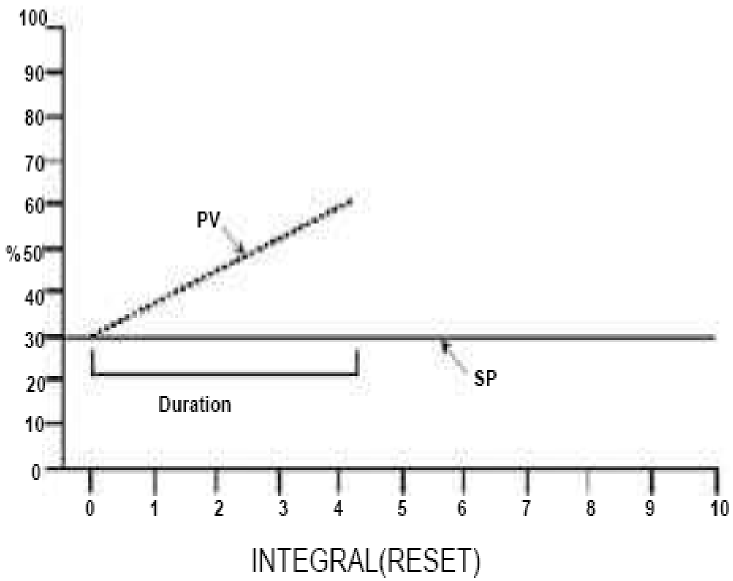


Controller Algorithms And Tuning

Tuning Parameters

Integral Control

The controller output from the integral or reset mode is a function of the duration of the error.



Controller Algorithms And Tuning

Tuning Parameters

Integral Control

Reset or Integral action, may be expressed in terms of:

Repeats Per Minute - How many times the proportional action is repeated each minute.

Minutes Per Repeat - How many minutes are required for 1 repeat to occur.

Controller Algorithms And Tuning

Tuning Parameters

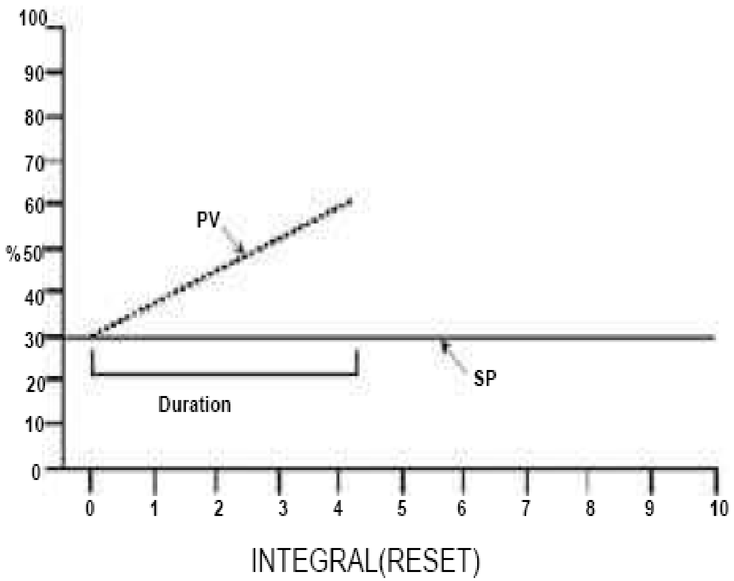
Integral Control

Reset action is described mathematically as follows:

$$\frac{dV}{dt} = K_i e$$

<u>Where</u>

dV/dt = the derivative of the valve position with respect to time (t)
K_i = an adjustable constant



Controller Algorithms And Tuning

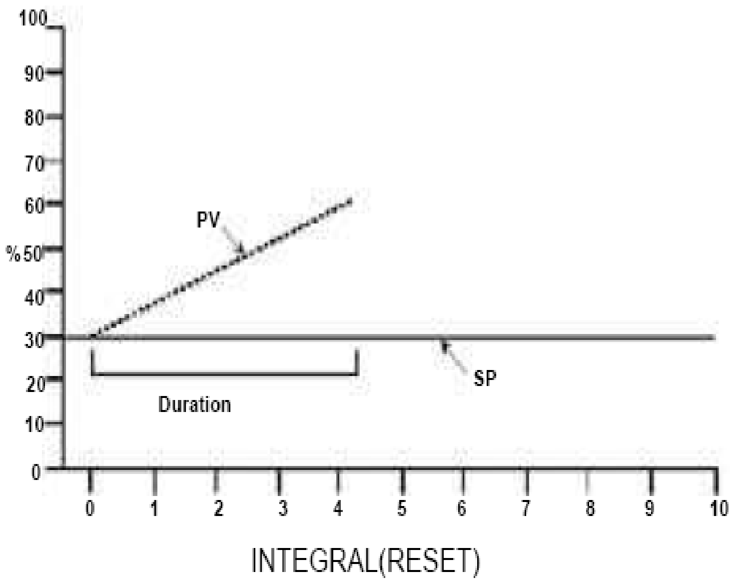
Tuning Parameters

Integral Control

$$\frac{dV}{dt} = K_i e$$

The position of the valve at any time can be obtained by integrating this differential equation from time 0 to time t.

$$V = K_i \int_0^t e\,dt$$



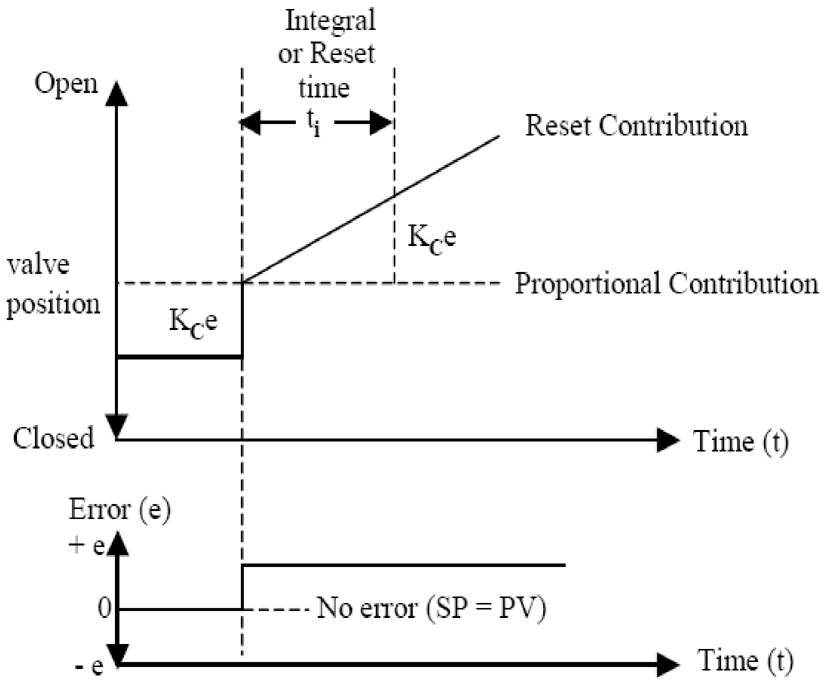
Controller Algorithms And Tuning

Tuning Parameters

Proportional-Plus-Integral Control

Reset or Integral action is usually used in conjunction with proportional control because it eliminates the offset.

Process control systems personnel refer to reset time as the integral time and denote it as t_i



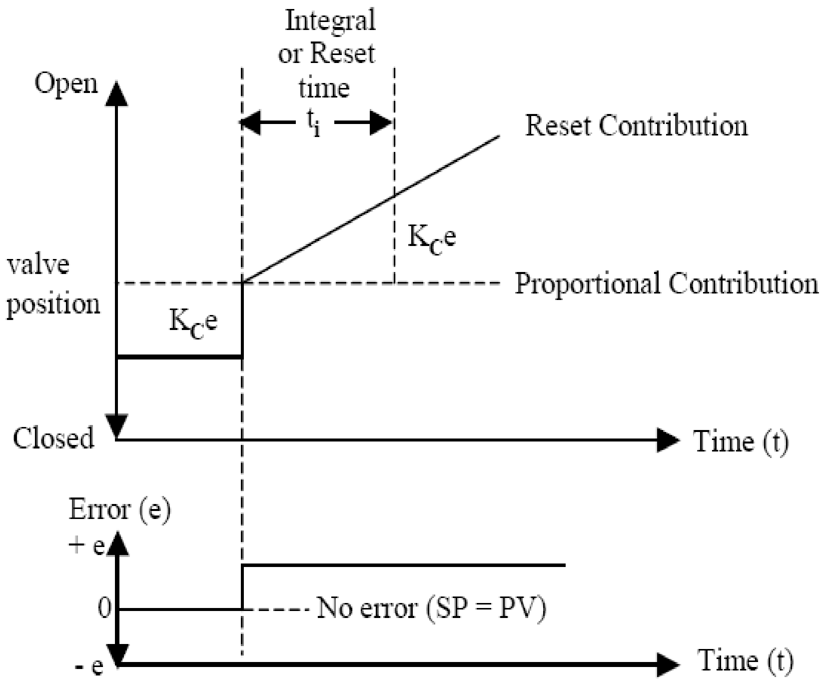
Controller Algorithms And Tuning

Tuning Parameters

Proportional-Plus-Integral Control

The total expression of a two-mode proportional-plus-integral (PI) controller:

$$V = K_c e + K_i \int_0^t e\,dt$$



Controller Algorithms And Tuning

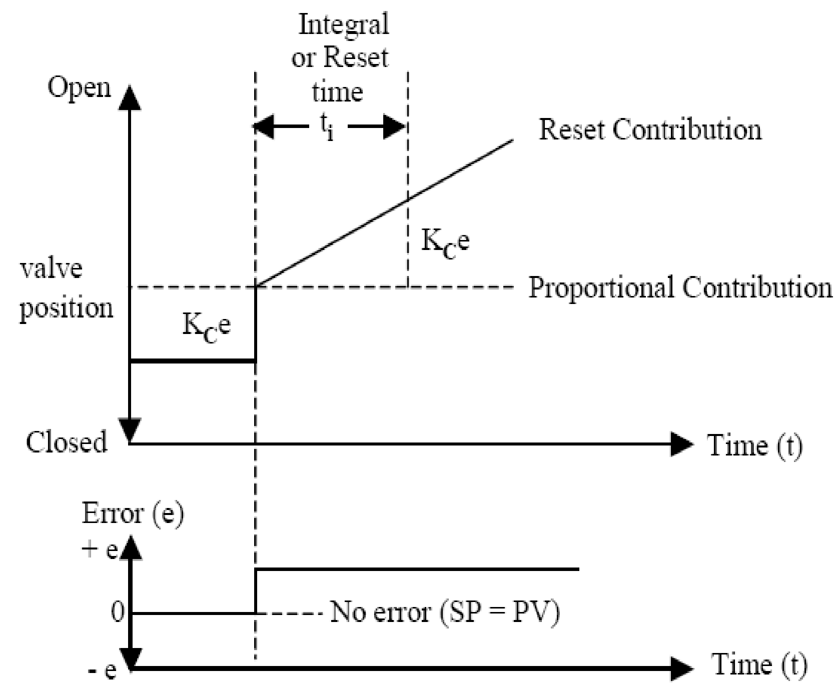
Tuning Parameters

Proportional-Plus-Integral Control

If we let $K_i = K_c/t_i$

The PI control equation will be as follows:

$$V = K_c e + \frac{K_c}{t_i}\int_0^t e\,dt$$



K_c = proportional gain

t_i = integral time

Controller Algorithms And Tuning

Tuning Parameters

Proportional-Plus-Integral Control

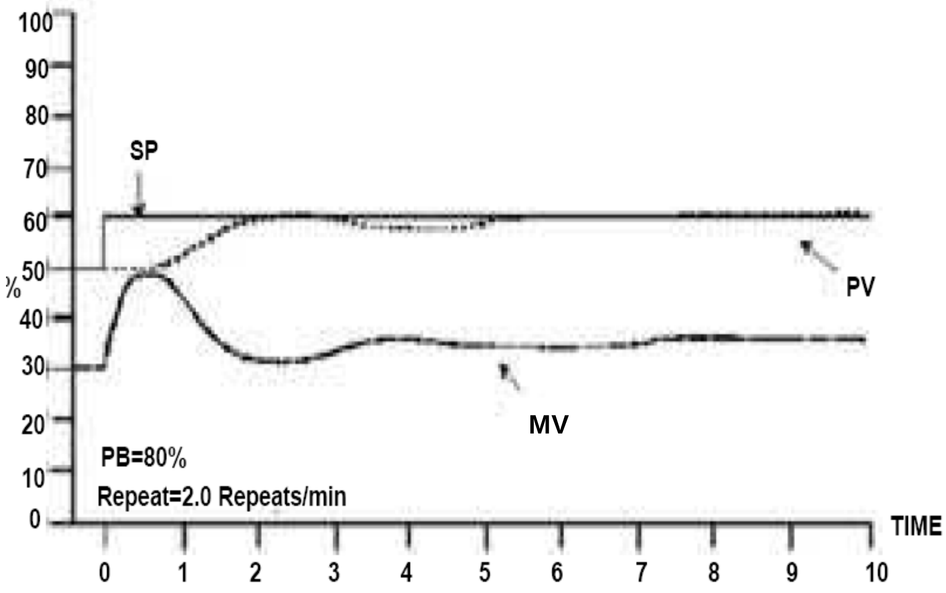
Slow Reset Example

Small Repeats/Min.
Large Min/Repeats.

1.Low Gain

2.Slow Return To Set point

3.Stable Loop



Controller Algorithms And Tuning

Tuning Parameters

Proportional-Plus-Integral Control

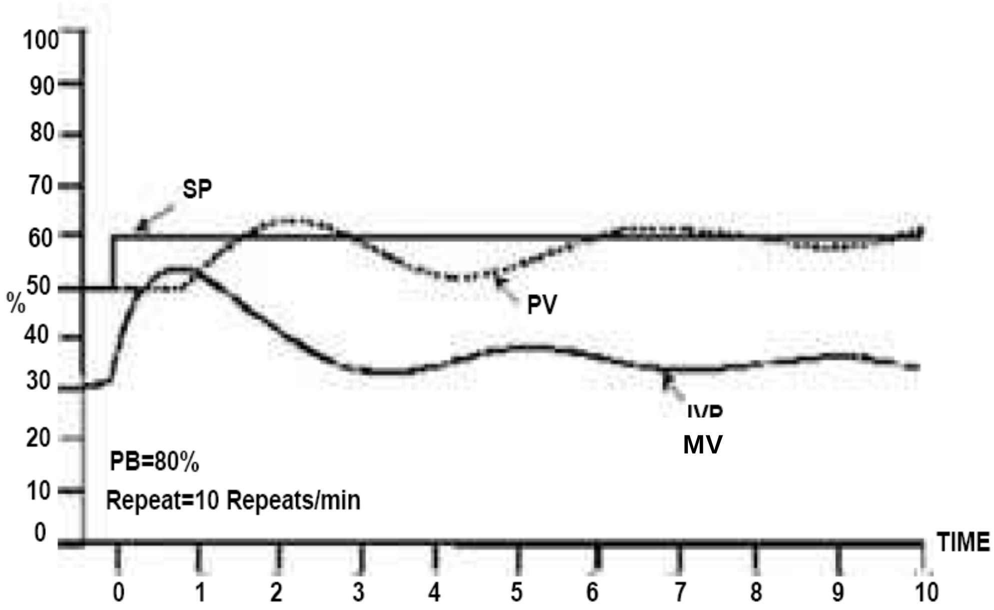
Fast Reset Example

Large Repeats/Min.
Small Min/Repeat

1.High Gain

2.Fast Return To Set point

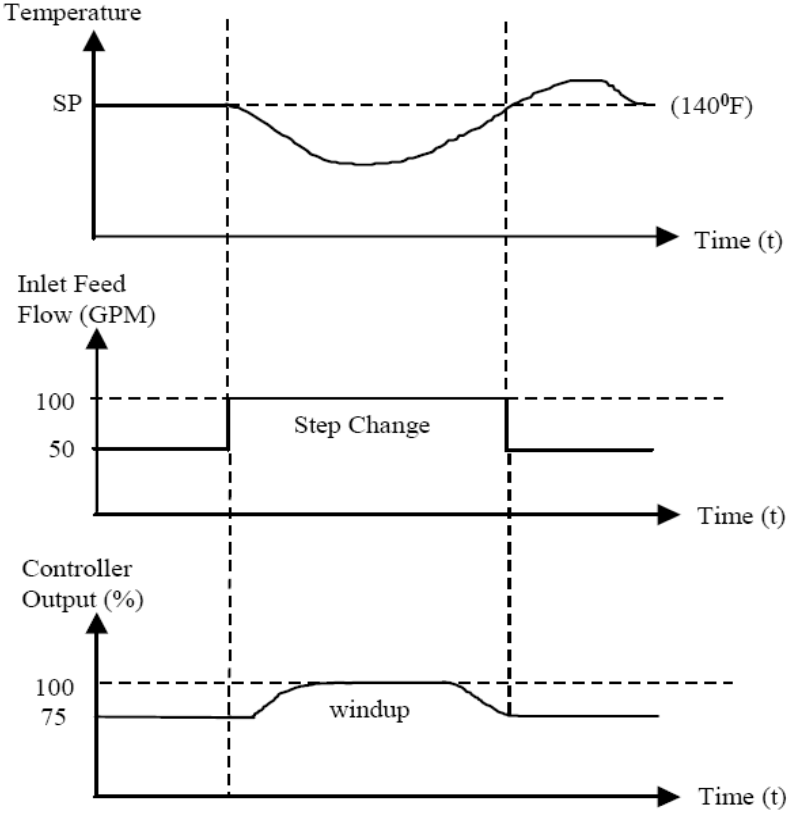
3.Possible Cycling



Controller Algorithms And Tuning

Tuning Parameters

Proportional-Plus-Integral Control



Advantages - Eliminates offset error

Disadvantage Reset Windup

Controller Algorithms And Tuning

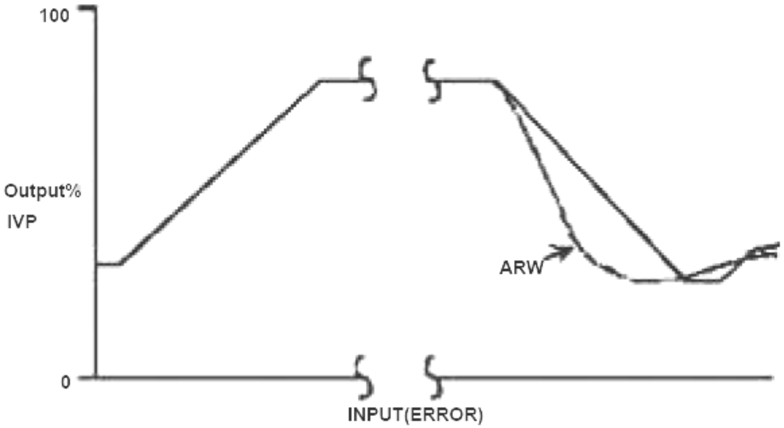
Tuning Parameters

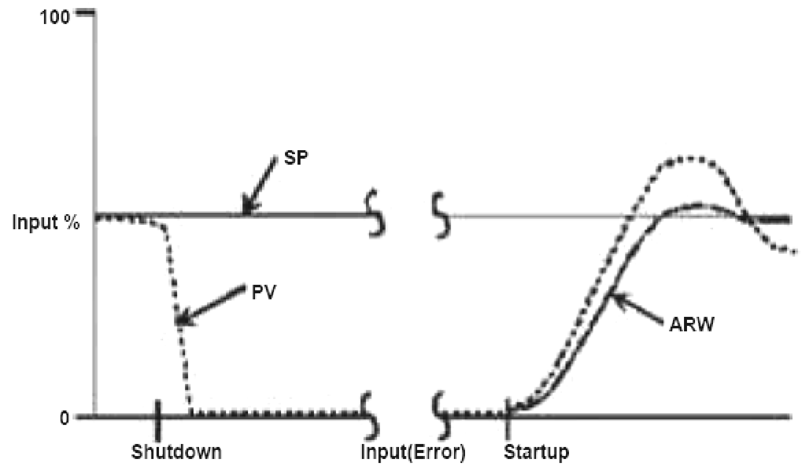
Proportional-Plus-Integral Control

Reset Windup - The controller will continue to integrate and change the output even outside the operating range of the controller.

Anti Reset Windup - (ARW) a controller operational feature that limits the integration and the controller output.

The purpose of an anti-reset option is to allow the output to reach its desired value quicker, therefore minimizing the overshoot.





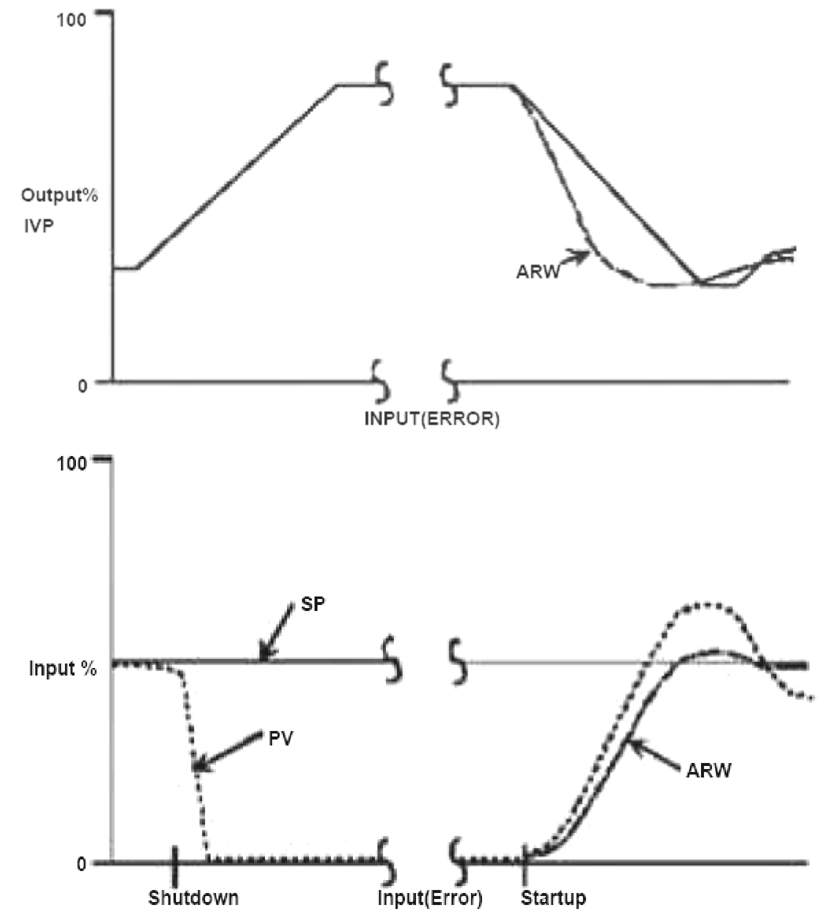
Controller Algorithms And Tuning

Tuning Parameters

Proportional-Plus-Integral Control

Anti Reset Windup - (ARW)

In older pneumatic controllers this was a problem .It normally is only associated with the extreme ends of the controller output ie <3 Psi and > 15 PSI. For instance if the controller air supply is 20 PSI then the output of the controller will eventually reach 20 PSI due to integral action (Reset) this leaves 3 PSI to vent before we come back to the controlling area of say 3-15 PSI.



Controller Algorithms And Tuning

Tuning Parameters

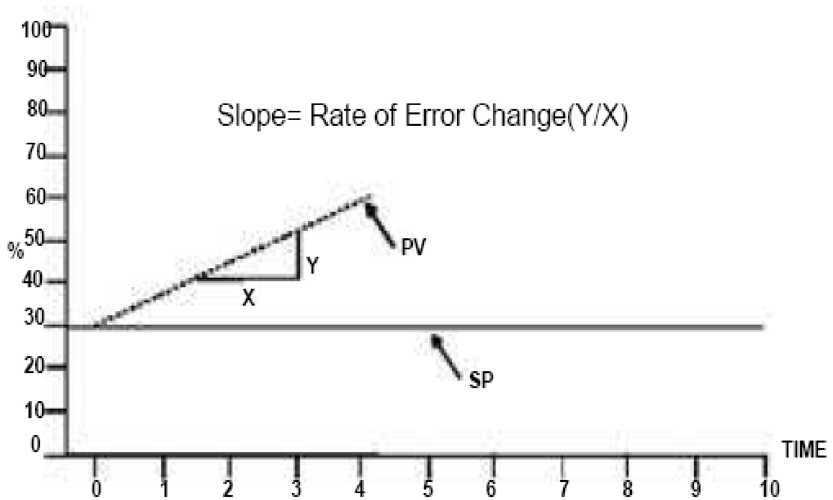
Derivative Control

This control function produces a corrective action that is proportional to the rate of change of error

This additional correction

I. Exists only while the error is changing

II. Disappears when the error stops changing even though there may still be a large error.



Derivative Action is based on the rate of change in Error (Y/X)

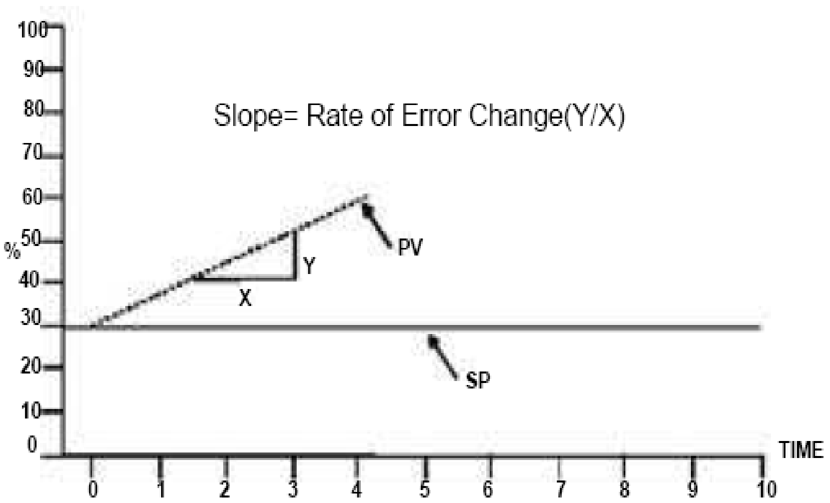
Controller Algorithms And Tuning

Tuning Parameters

Derivative Control

The derivative constant K_d can be related to the proportional constant K_c by the following equation:

$$K_d = K_c t_d$$



Derivative Action is based on the rate of change in Error (Y/X)

<u>Where</u>

K_d = the derivative constant

de/dt = the derivative of the control system error with respect to time

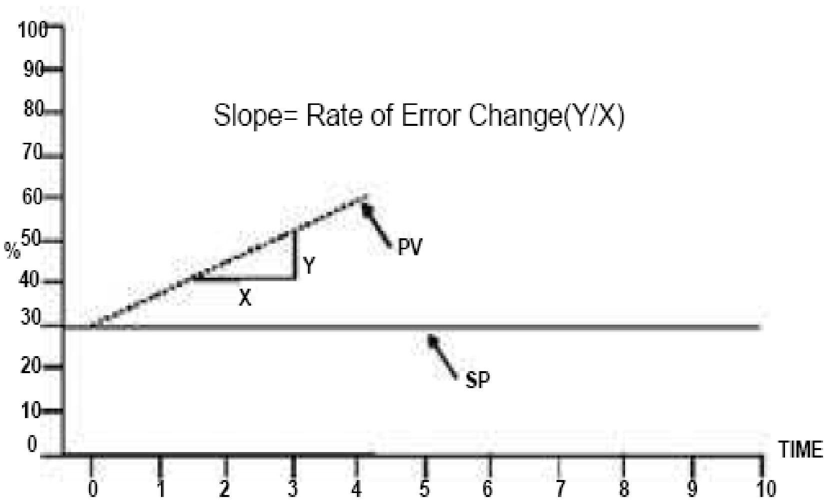
Controller Algorithms And Tuning

Tuning Parameters

Derivative Control

Derivative control can be expressed mathematically as follows:

$$V = K_d \frac{de}{dt}$$



Derivative Action is based on the rate of change in Error (Y/X)

<u>Where</u>

K_d = the derivative constant

de/dt = the derivative of the control system error with respect to time

Controller Algorithms And Tuning

Tuning Parameters

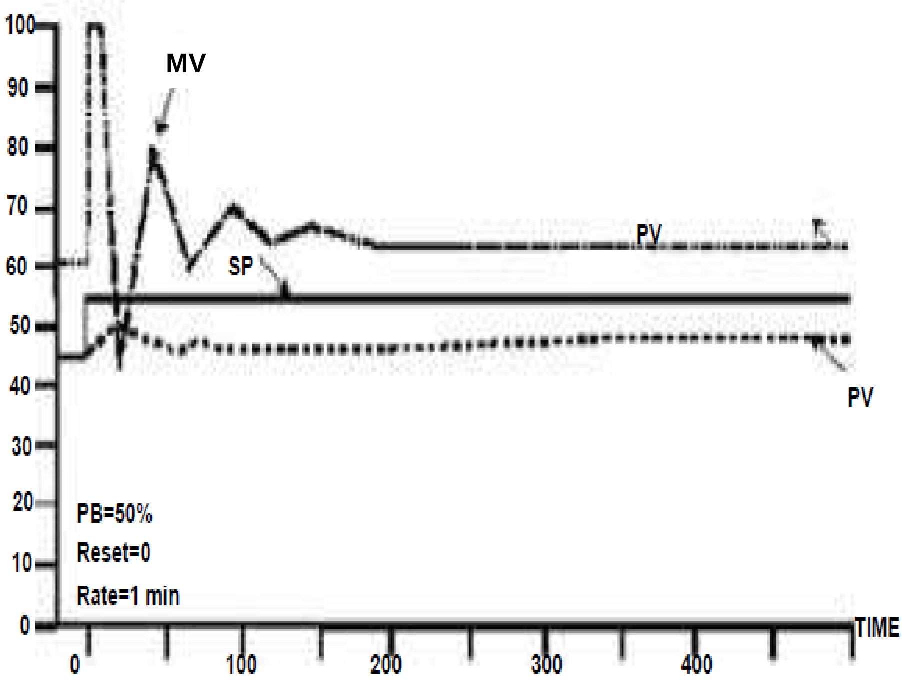
Proportional-Plus-Derivative Control

Small (Minutes)

1.Low Gain

2.Small Output Change

3.Stable Loop



Controller Algorithms And Tuning

Tuning Parameters

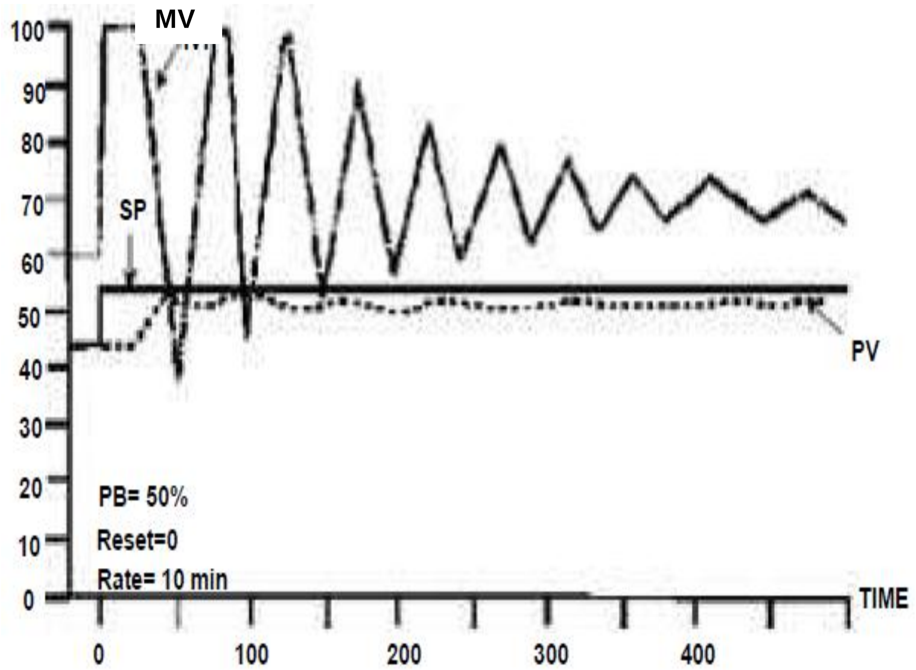
Proportional-Plus-Derivative Control

Large (Minutes)

1.High Gain

2.Large Output Change

3.Possible Cycling



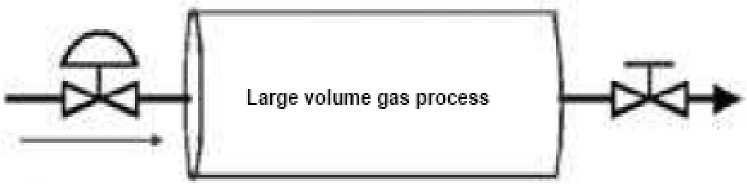
Controller Algorithms And Tuning

Tuning Parameters

Proportional-Plus-Derivative Control

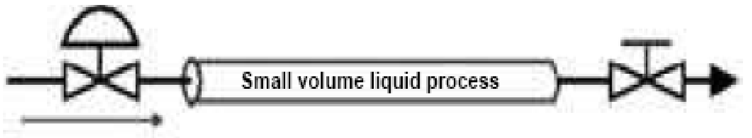
Advantages –

Rapid output reduces the time that is required to return PV to SP in slow process.



Disadvantage –

Dramatically amplifies noisy signals; can cause cycling in fast processes.



Controller Algorithms And Tuning

Tuning Parameters

Proportional-Integral-Derivative Control

Derivative control can be expressed mathematically as follows:

$$V = K_c e + \frac{K_c}{t_i}\int_0^t e\,dt + K_c t_d \frac{de}{dt}$$

<u>Where</u>

K_d = the derivative constant

de/dt = the derivative of the control system error with respect to time

Controller Algorithms And Tuning

Tuning Parameters

Proportional-Integral-Derivative Control

By using all three control algorithms together, process operators can:

1. Achieve rapid response to major disturbances with derivative control
2. Hold the process near set point without major fluctuations with proportional control
3. Eliminate offset with integral control

Controller Algorithms And Tuning

Tuning Parameters

Proportional-Integral-Derivative Control

Types of control loops and types of control algorithms are typically used.

Controlled Variable	Proportional Control	PI Control	PID Control
Flow	Yes	Yes	No
Level	Yes	Yes	Rare
Temperature	Yes	Yes	Yes
Pressure	Yes	Yes	Rare
Analytical	Yes	Yes	Rare

Thank You