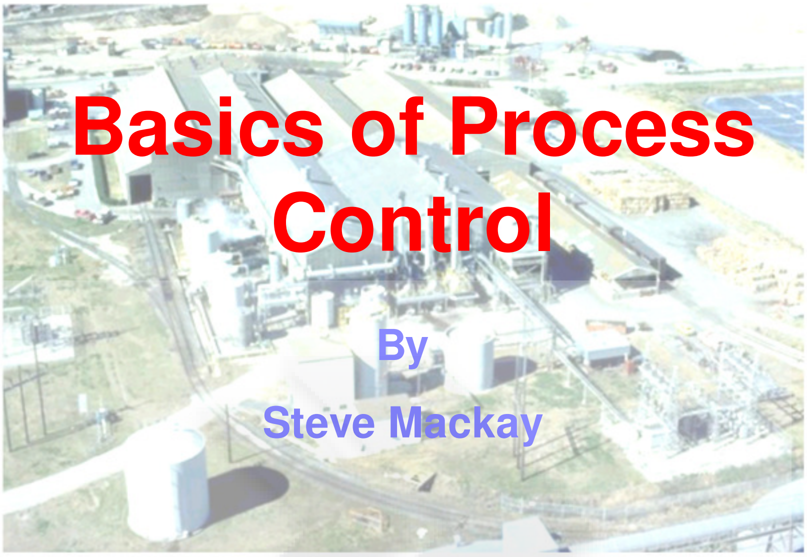

Basics of Process Control

By

Steve Mackay

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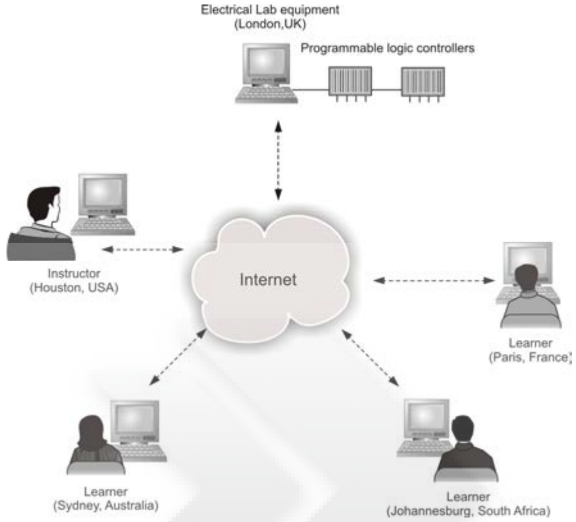
The Concept



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Objectives

- Introduction to Process Control
- Tuning
- Cascade loops
- Dead time issues

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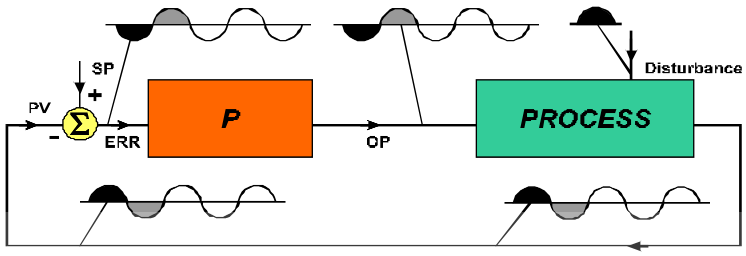
Loop Controller and Process



Steps to instability:

Disturbance shows on PV

Controller calculates from ERR the OP

The OP becomes effective with 180° phase shift on PV

The change on PV is now treated like a disturbanc
Controller calculates from ERR the OP

Above steps repeat and continue - We have instability !!

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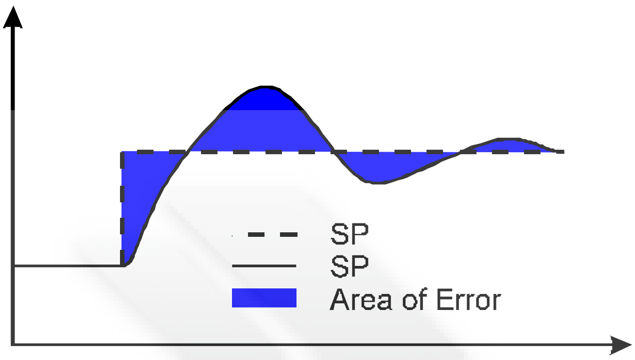
Objectives of Tuning (1)

1 - Minimize Integral of error



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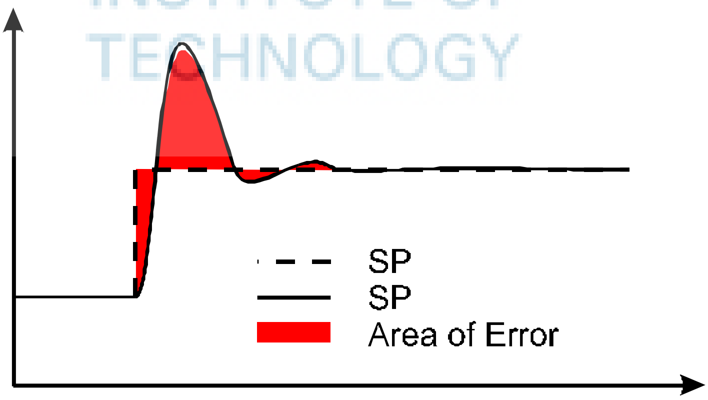
Objectives of Tuning (2)

2 - Minimize Amplitude of error squared



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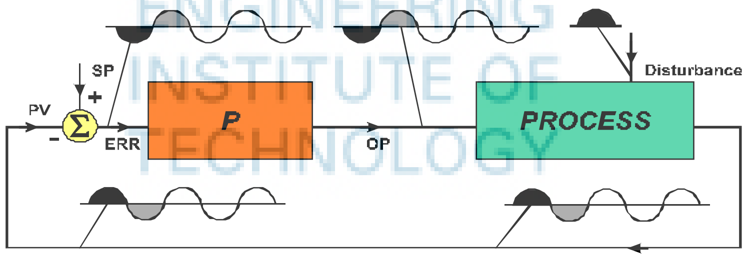
Other Aspects of Tuning (3,4,5)

3 - Minimize wear and tear

4 - No overshoot at Start Up

5 - Minimize effect of known disturbances

Loop Controller and Process



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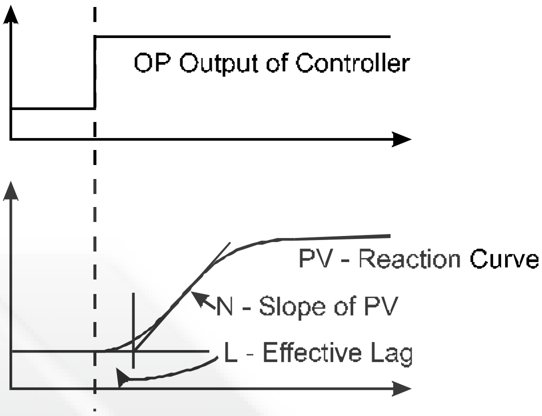
Steps of Open Loop Tuning (Reaction Curve)

1. Put controller in **manual** mode
2. Make a **step change** to the OP value
3. Observe Reaction Curve
4. Calculate timing constants

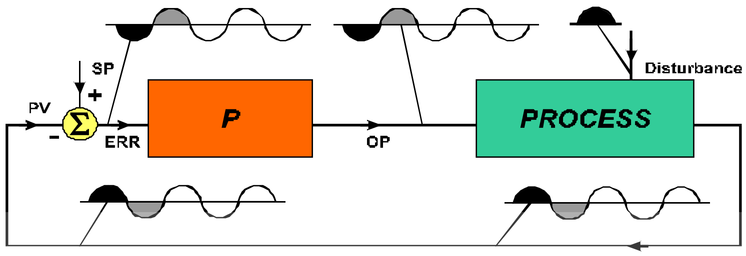


Reaction curve

Continuous Cycling - Ziegler & Nichols

- Find critical value of K for continuous oscillations
- Do not use I or D - control
- Observe critical frequency for 180° phase shift
- Stabilize loop by reducing K and ensure that I & D
  - control still gives a phase lead

P-only for Continuous Cycling Method



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Continuous Cycling Method

1. Put controller in P - control only
2. P - control on ERR = (SP - PV)
3. Controller in Auto
4. Step change to SP
5. Double value of K until continuous cycling
6. Calculate tuning constants

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Calculation of Tuning Constants

P - Control $K_C = 0.5 \times K_U$

PI - Control $K_C = 0.45 \times K_U$

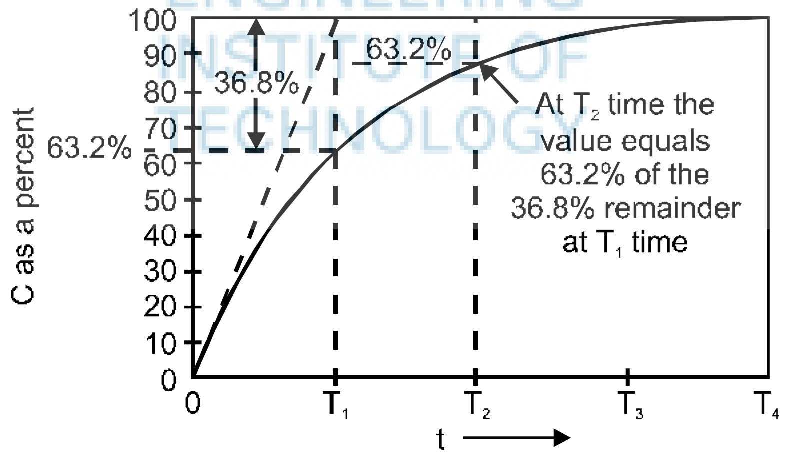
$T_{\text{int}} = P_U / 1.2$

PID - Control $K_C = 0.6 \times K_U$

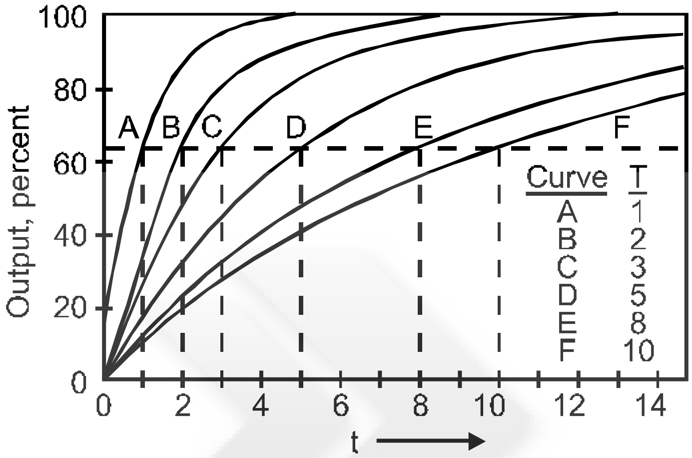
$T_{\text{int}} = P_U / 2$

$T_{der} = P_U / 8$

First Order Lag



First Order Lag Response Curve



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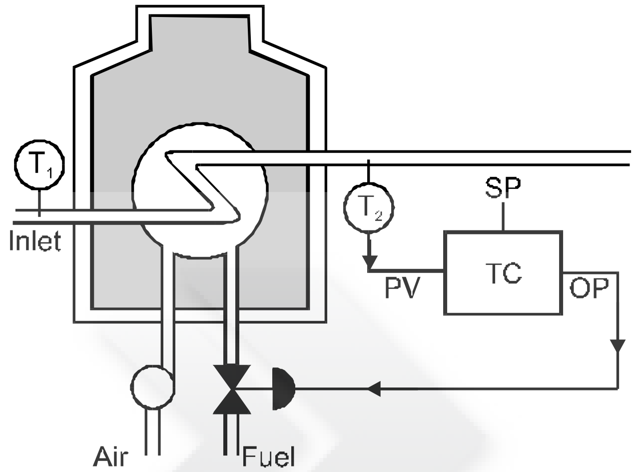
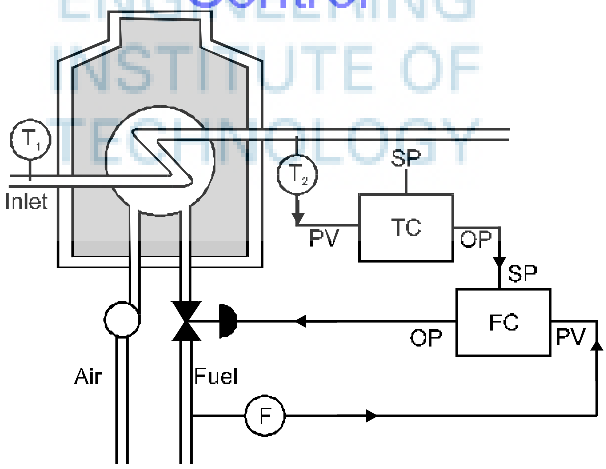
Single Loop Temperature Control



Two Controller Basic Cascade Control



Tuning of Cascade Loops (cont…)

- Cascade Control - Secondary Controllers
  - Mainly flow controller
  - No D - control as mainly stable
  - K < 1
- Cascade Control - Primary Controllers
  - Mainly PID controller
  - Careful stability considerations

Process Deadtime

- Difficult problem to overcome long deadtime in feedback control loop
- Especially when deadtime more than 20% of total time taken for PV to settle to its new value after last setpoint change

Example of Process Deadtime

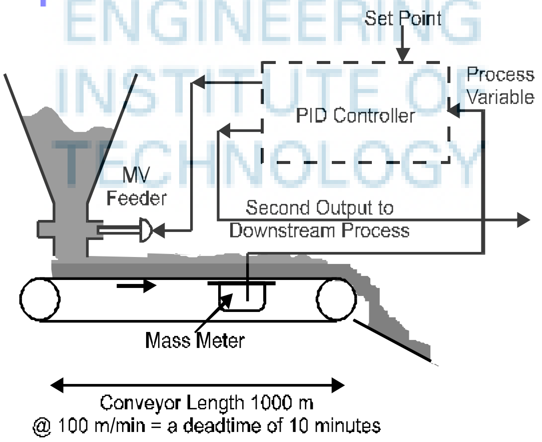


Illustration of a long conveyor system giving an excessive deadtime to the control loop

Overcoming Process Deadtime

- Depends on operating requirements of process
- Easiest solution: de-tune controller to slower response rate so that controller will not over compensate unless deadtime excessively long
- Integral mode of controller very sensitive to deadtime since during period of PV inactivity, integrator ramps output

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