Process Control Learning Platform Using LabVIEW Based Control Systems

Houran, Nadeem + Powers, Jessica

Professor Craig Gates and Dr. Philip Harding

School of Chemical, Biological and Environmental Engineering

An Educational Learning Device Designed and Imagined By Students For Students

Objective

•Issue: There is no current lab experience to reinforce concepts of process control or LabVIEW programming in the School of CBEE at OSU.

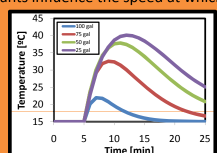
•Solution: A bench-top control system researched, designed and constructed to demonstrate the practical use of process control and LabVIEW to seniors.

Background

$$v = P\varepsilon - I\int_0^t \varepsilon\,dt + D\frac{d\varepsilon}{dt}$$

Equation above defines a PID control system where *v* is the response and *ε* is T_{sp}-*T(t)*. The *P*,*I* and *D* constants influence the speed at which the setpoint is achieved.

$$v = v_{t-1} \pm K_p\left[\left(1+\frac{\Delta t}{\tau_I}+\frac{\tau_D}{\Delta t}\right)\cdot\varepsilon\right]$$



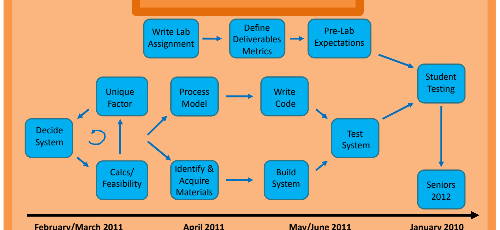
Presented above is a form of the PID control system allowing for easy programming. Expression evaluates the previous response and adjusts its value based on the error, ε. K_p, τ_I and τ_D can be approximated from the process transfer function using methods like **Ziegler–Nichols method.**

The two equations presented below are the non-integrated and integrated forms of the process model assuming constant volume direct injection steam heating. Q(t) is a function of the steam valve lift.

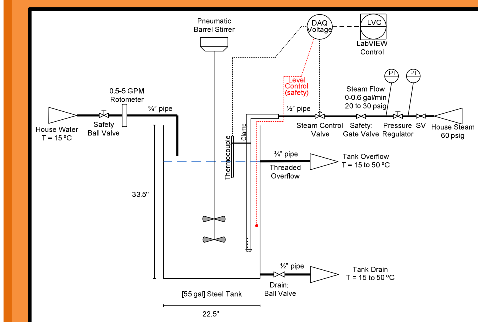
$$\frac{dT}{dt} = \frac{w_i}{V_b\rho_b}(T_i - T) + \frac{Q(t)}{V_b\rho_b C_p}$$

$$T(t) = T_0 + \dot{m}_{steam}(t)\cdot\frac{\Delta H_{v,w}}{V_b\rho_b C}\cdot e^{\frac{w_i}{V_b\rho_b}t}$$

Methods



Process Flow Diagram

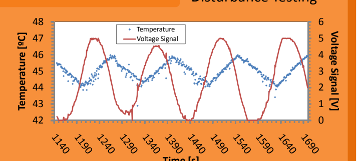


Figures: (on the left) A P&ID (piping and instrumentation diagram) with dimensions. (above) The actual lab equipment constructed in Gleeson's basement.

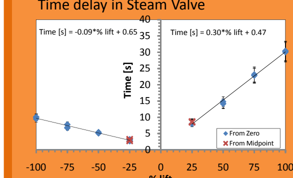
LabVIEW Programming

Front Panel

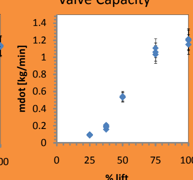
Disturbance Testing



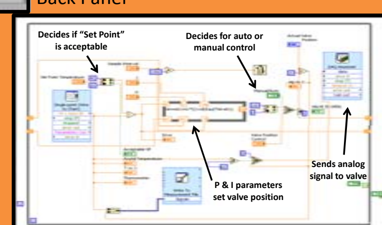
Time delay in Steam Valve



Valve Capacity



Back Panel



• Students expected to generate plots similar to these.

Problem Statement

A 15 °C liquid process line for Beaver Manufacturing contains a holding tank, which requires a constant temperature of 45 °C. The process input is constantly changing, requiring the use of PI parameters to maintain the desired steady state temperature through the input of pressurized steam. Your goal is to characterize the steam valve and optimize the PI parameters.

Conclusions

•Currently:
- •Lab equipment constructed.
- •Steam experiments completed:
  - •Steam flowrate optimized, achieved 3 °C/min
- •LabVIEW Programming:
  - •Front panel "GUI" completed.
  - •Initial block diagram written with proportional and integral control (not derivative), but not tested.
- •Required documents written for lab to be operational next year:
  - •Project Deliverables
  - •Pre-lab Assignment
  - •Lab SOP (standard operating procedure)
- •System tested and results consistent with theory

•Long-Term Goals:
- •Add additional capability to the lab in the form of level control.
- •Incorporate derivative control into the LabVIEW program.

Acknowledgements

•Andrew Brickman, Instrument Technologist
•Professor Craig Gates, Project Sponsor
•UC Boulder – Dr. David E. Clough
•Katherine McAuliffe, OSU ChE Student
•Dr. Philip Harding, Senior CBEE Lab Professor