

ChE 436 Lab Project 1

Armfield Level Control

This process control lab is located in the south end of the UO Lab. You are to work on this project in groups of four, and turn in a common report for the group. The purpose of this project is to reinforce the concepts taught in class about process time constants and controller tuning constants. A write-up is required, showing all data, equations used, and intermediate and final results.

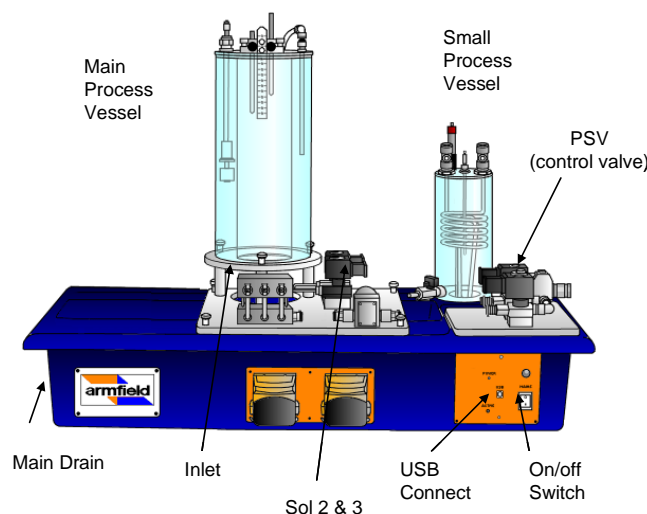
Grading

This lab will count for 10% of your grade. Reports will be graded for accuracy and professionalism.

Problem Statement

1. Perform a mass balance for the gravity drained annular tank.
2. Solve the mass balance by linearizing and using a Laplace transform to get expressions for the time constant (τ_p) and process gain (K_p).
3. Perform a step test on the PCT 40 for the gravity drained tank in manual mode. Make a graph in Excel to turn in with the report.
4. From the manual-mode step test calculate FOPDT constants (τ_p , K_p , θ_p) (see Practical Process Control manual). You can use Control Station if you like.
5. Use the measured value of K_p to get a value for $C_v f(l)$ in the derived expression, and compute a value of τ_p from your expression in Step 2. Comment on how this compares with the measured value.
6. Obtain PI tuning constants from the correlations given in the Control Station manual.
7. Using those tuning constants, implement a PI controller on the PTC 40. See the note below on Proportional Band (PB) because it is different than implementing a controller gain (K_c). Start with a set point of 150 mm and then check for changes in set point both above and below that value (100, 200 mm)
8. Comment on the performance of the PI controller using the calculated constants.

Equipment: Armfield PTC 40



Instructions

Double click the PTC 40 Basic Process..... icon on the left hand side of the desktop. Select Section 2 and click load

On the main control bar the following are important icons:



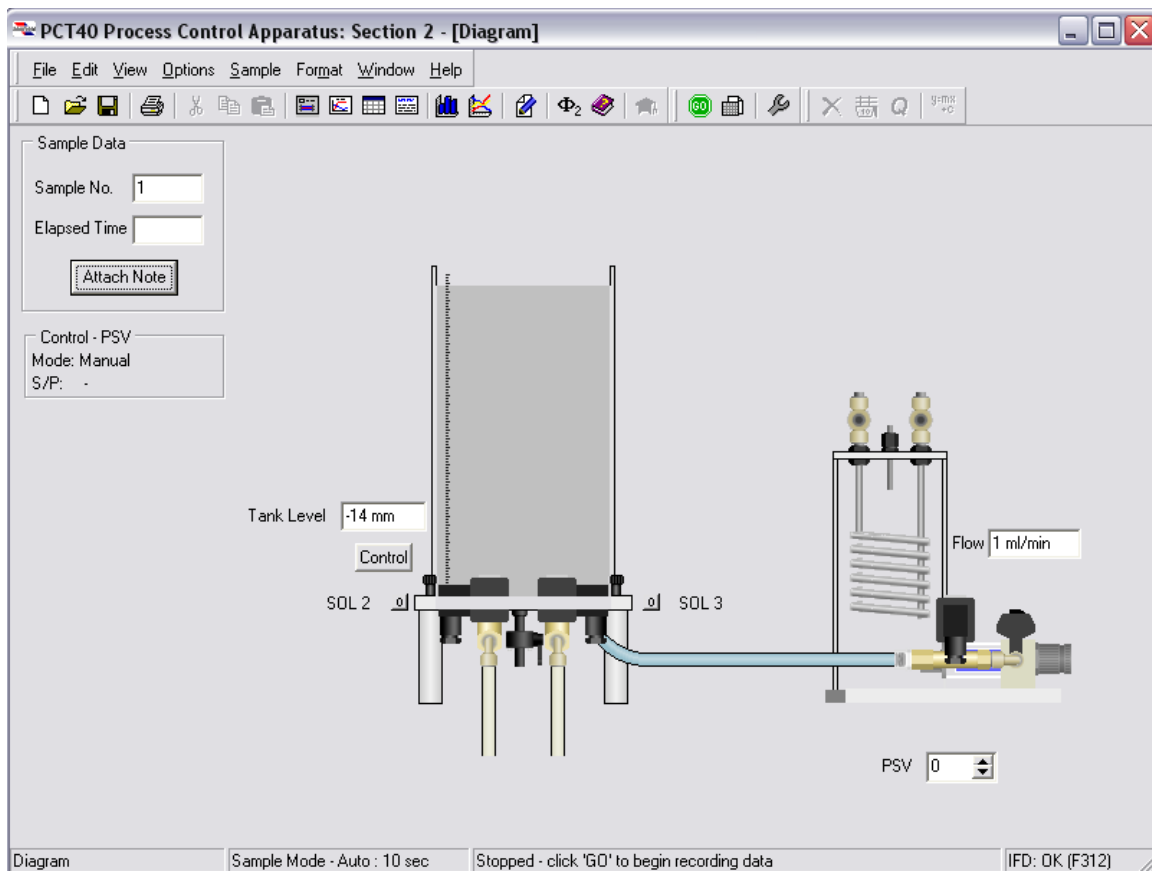
From left to right the buttons are

Mimic Diagram | Graph | Table | Start data collection | Start new data set | Configure data collection

How to control the process

Make the tube labeled “Inlet” is connected at the front left of the main process vessel

Click on the mimic diagram button and the following screen should appear:



From this screen one can:

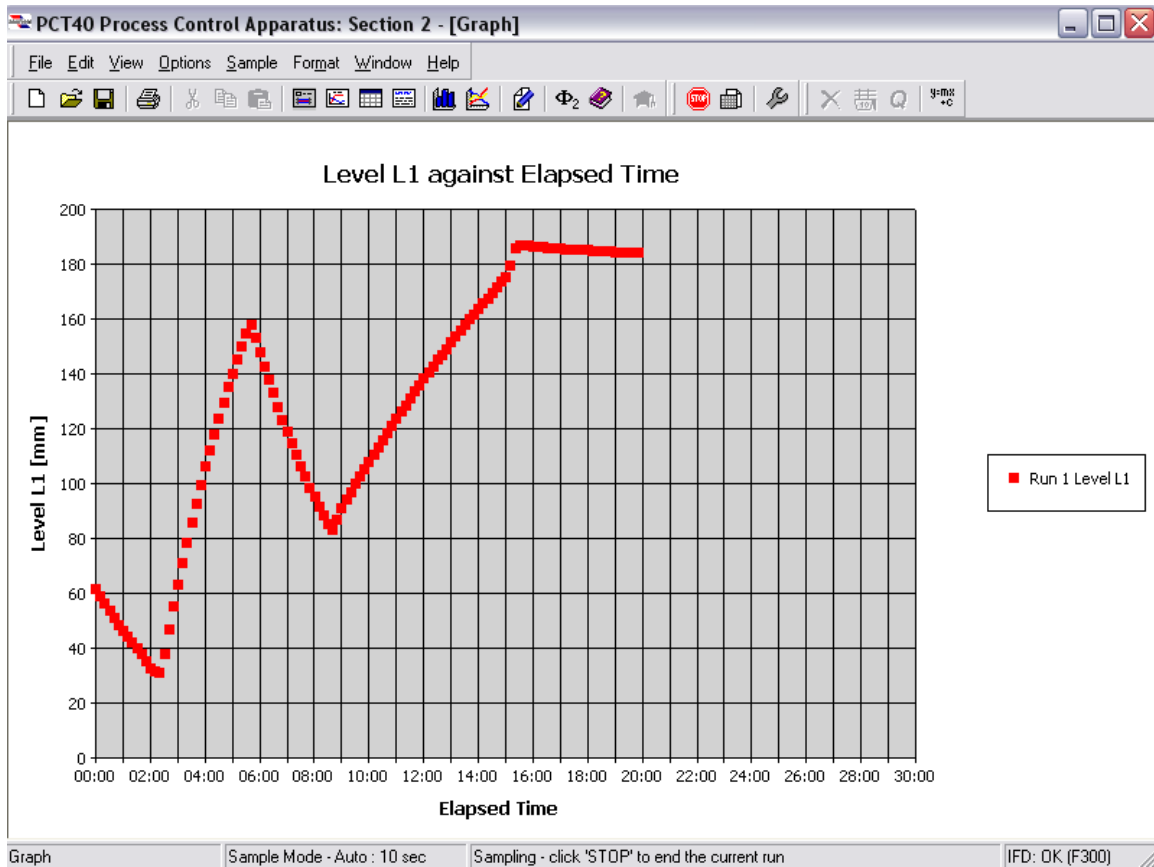
- Control PSV output
- View the inlet flow rate
- View the tank level
- Start disturbances

To begin filling the vessel click in the box labeled PSV and enter the value of 100.

Click the Go button to begin recording data.

Fill the vessel to 100 mm then balance the inlet and outlet flows by adjusting the PSV and the drain (Hint: Keep the drain at a fixed position once it is partially closed, then adjust the PSV percentage)

While data is recording you can click on the graph button and a graph such as the one below will appear. When the level begins to flatten out for several minutes a step test can be conducted. To see the data on the graph and more click on the table button. When you are finished with the step test click the stop button (as seen below) and save the file as an Excel spreadsheet (you will need to change from the default file type in the program).



Click on the control tab next to the mimic process vessel. This screen should appear:

Process Variable: Tank Level
Control Variable: PSV
Control Action: Reverse

Mode of Operation:
 Automatic
 Manual

Settings | Calculations

Automatic Operation:
Set Point: 200.0 mm
Proportional Band: 10 %
Integral Time: 0 Secs
Derivative Time: 0 Secs

Manual Operation:
Manual Output: 0 %

Apply Save Restore Default
OK Cancel Help

When you are ready to input PID settings into the program change the mode of operation from manual to automatic. The PID tuning constant for the proportional term is listed as a **Proportional Band**. This is common with some equipment manufacturers but has a different definition than what we have typically used for tuning constants in this class (see Section 5.9 of Practical Process Control).

Automatic Operation:
Set Point: 200.0 mm
Proportional Band: 10 %
Integral Time: 0 Secs
Derivative Time: 0 Secs

Proportional Band (PB) relates to the controller gain (K_c) by the following relationship:

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

Setting the Integral Time and Derivative Time to 0.0 creates a Proportional-only controller with the following Controller Output (CO):

$$CO = CO_{bias} + K_c (SP - PV) = CO_{bias} + \frac{100}{PB} (SP - PV)$$

With $PB=10.0\%$, the valve position (CO) will change by 10% with a level change of $1mm$. The Integral Time and Derivative Time are also adjustable tuning constants and are consistent with the tuning parameters τ_I and τ_D from the standard PID equation.

Use the start new data set button to start a new spread sheet for the PI controller values. Click the GO button when you are ready to collect data.

Cleanup

When you are finished with the experiment set the PSV value to 0 and allow the tank to drain. Turn the mains on/off switch. If you are the last group for the day shut down the computer.

Scheduling

PLEASE do not leave this until the last day.