**Purpose:**

Using the flow calibration set up for the transmitter from the previous Flow lab (0-5 GPM), the student will set up a controller for automatic control of the flow to a tank. The student will approximate the **Ultimate Gain** and **Ultimate Period** and compute stable controller tuning parameters for a **Proportional Only** controller and **Proportional-Integral** controller. The performance of each controller will be evaluated.

**Procedure:**

**Manual Mode:**

1. Setup – HV-1, Closed; HV-2, Closed; HV-3, Open, HV-4, Open.
2. From the HMI, set controller to Manual Mode. Position the control valve to 100% open.
3. Start the pump and adjust the speed until there is 5 GPM flow.
4. Assign a student to manually control the flow to 3 GPM by adjusting the control valve from the HMI screen. Record the valve setting. \_\_\_\_\_\_\_\_\_\_\_\_%
5. Assign a second student to manually Introduce a disturbance by throttling HV-3.
6. When the disturbance decreases flow, what action did the controller require? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. When the disturbance increases flow, what action did the controller require?
8. Is this a direct or reverse acting process?
9. Based on the answer in #8, does the process require a direct or reverse acting controller?

**Auto Mode:**

In order to operate the system in the Auto Mode, tuning parameters must be identified.

1. Adjust the control valve while in the manual mode until the flow is equal to approximately 50%.
2. Enter an initial controller gain of 1.0.
3. Enter a set-point of 50% and place the controller in the Auto Mode.
4. Once the process is stable, adjust the set-point to 60%. Monitor the controller behavior on the HMI trend for a couple of minutes. How would you describe the controller behavior? \_\_\_\_\_\_\_\_\_\_
5. This gain is a close approximation of the Ultimate Gain. Record this value: \_\_\_\_\_\_ Estimate the Ultimate Period using a stop watch and record this value: \_\_\_\_\_\_\_\_\_\_\_

Proportional Only Controller:

1. Using the Z-N formulas, calculate the controller Gain for a **Proportional Only** Controller (Kc = Ku/2): Record the result: \_\_\_\_\_\_\_\_\_\_
2. For a proportional-only controller, what output do you expect for a 10% change in process variable? (CV = Kc \*error) \_\_\_\_\_\_\_\_\_\_
3. Perform the setpoint changes listed and record the results:

|  |  |  |
| --- | --- | --- |
| Setpoint | Controller Output | Process Variable |
| 50% |  |  |
| 40% |  |  |
| 50% |  |  |
| 60% |  |  |

1. Did the controller ever eliminate any error between the Setpoint and Process Variable? \_\_\_\_\_\_\_\_\_\_ If so, at what setpoint? \_\_\_\_\_\_\_\_\_\_

Proportional-Integral Controller

1. Using the Z-N formulas, calculate the controller Gain for a **Proportional-Integral** Controller (Kc = Ku/2.2): Record the result: \_\_\_\_\_\_\_\_\_\_
2. Using the Z-N formulas, calculate the controller Integral time for a Proportional-Integral Controller (Ti = Pu/1.2): Record the result: \_\_\_\_\_\_\_\_\_\_
3. Perform the setpoint changes listed and record the results:

|  |  |  |
| --- | --- | --- |
| Setpoint | Controller Output | Process Variable |
| 50% |  |  |
| 40% |  |  |
| 50% |  |  |
| 60% |  |  |

1. Did the controller ever eliminate any error between the Setpoint and Process Variable? \_\_\_\_\_\_\_\_\_\_ If so, record the set-point? \_\_\_\_\_\_\_\_\_\_ (Note: when the SP=PV, it is possible that the deviation is off by a small amount which can be due to process noise, or a poor control valve characteristic.)

Review Questions:

1. Did the Z-N values provide a stable system?
2. Explain Ultimate Gain.
3. Which control loop performed best?
4. What does PID stands for \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?
5. Ti stands for \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?
6. Kc stands for \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?
7. The desired flow rate in a process is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?
8. With a flow measurement range of 0-5 GPM what would be the current signal from the transmitter at 3 GPM?
9. What does PV stand for? \_\_\_\_\_\_\_\_\_\_\_\_\_.
10. What does SP stand for? \_\_\_\_\_\_\_\_\_\_\_\_\_.
11. What does CV stand for? \_\_\_\_\_\_\_\_\_\_\_\_\_.