LABORATORY EXERCISE 8
OPEN LOOP TUNING

The System

In this laboratory study, you will perform an open loop analysis of a small airflow system. The controller used in this study is a KMC Model 5501. This is a general purpose controller designed primarily for HVAC duty. However, since it is general purpose, the user must write a program to tell the controller how to handle the inputs and outputs. This program already exists; you will not need to modify the program. The controller has 8 inputs and 8 outputs. The input and outputs are configurable as digital or analog points. If configured as an analog point, they may be configured for current or voltage. In the present case, all inputs and outputs are configured for voltage. The human interface to the controller is via a PC and KMC's proprietary software known as WinControl. Your instructor will explain its use.

The input to the controller is from a TCS pressure transmitter with a sensing range of 0 to 2 inches w.g. And an output of 4 to 20 ma. The current output of the sensor is converted to a voltage input to the controller by means of a shunt resistor.

The controller drives a 4 to 20 ma I/P valve which outputs 3 to 15 psi. Since the controller outputs voltage, a shunt resistor is placed across the controller output terminals so as to provide a current to the I/P.

The I/P valve drives a pneumatic actuator with a spring range of 3 to 12 psi. Note the actuator spring range and the output range of the I/P are not equal. As such, the gain determined from the loop analysis must be adjusted by a factor of 12/16 = 75%.

Procedure

<u>Controller Setup (Break the loop)</u>

- From the WinControl software, put the setpoint variable (SP) in manual. The setpoint variable is accessed through the variables dialogue.
- Put the controller output (DMPR) in manual. This output is accessed through the output dialogue.
- Remove any backlash from the system. Do this by driving the output to some low value (ie: 30%)
- Adjust the output so the damper is at about 60°. This should occur somewhere between 60% and 65% controller output.

<u>Strip Chart Recorder Setup</u>

- Set the long pen to the 2V range with an offset of +1 volt. This records the disturbance to the system.

- Set the short pen to the 1V range with an offset of +2 volt. This records the process variable (static pressure).
- Set the chart speed to 20 mm/sec.

Perform Test

- Make sure the system is lined out
- Start the chart recorder
- Bump the system by increasing output by 5%. If this proves unsatisfactory, try 10%.

Perform Analysis

- Perform a graphic analysis as instructed during lecture.
- Determine the values for a P and a PI controller
- Since the air damper motor has a 3-12 psi spring range, and the I/P outputs 3-15 psi, you must adjust the calculated gain by multiplying by a factor of 0.75. Take the inverse of this number as the percent proportional band you will enter into the controller software.

Check Results (P control)

- Enter K_c into the controller using the controller dialogue of WinControl.
- Place output #1 (DMPR) and the setpoint variable (SP) back to auto.
- On the right side of the control board is a switch marked 'Closed Loop' and 'Setpoint Reset". Make sure this switch is in the down position (off).
- A check of your tuning parameters in the closed loop must occur over the same range as the open loop test. To bring the damper to 60°, adjust the controller bias. A value of about 70% should work. (Note: This is what you did on the PCControLab PID simulation lab in the classroom.)
- From the Control menu in WinControl, open the Control Basic dialogue. Make sure Program #1 is 'On'. Open the program by clicking on the number '1' in the dialogue box. Locate the lines of code defining the reset schedule. Make sure reset schedules one through three are remarked out. Reset schedule #4 should NOT be remarked out.
- Set the recorder to a speed of 5 mm/sec. Leave the pen voltages as is.
- Drop the blue pen and start the recorder.
- After allowing a baseline to trace, flip the reset switch (on right side of controller board) up. This injects a setpoint disturbance via the reset schedule defined in the program code.

- After the resulting trace has lined out, flip the switch down and record the result.
- Repeat 3 more times.
- Select one of the four traces and determine the damping ratio. If the damping ratio is not 4:1, just accept the result as is. Record all of your results and keep your trace. We will use the 'As-Found' tuning method to tweak your results in a later lab.

Check Results (PI control)

Check the results for the PI parameters in the same way as you did above except:

- enter both K_c and T_i in the controller dialogue.
- Adjust the control bias back to 50%. The inclusion of integral should force the controller to position the damper at about 60°. If not, adjust the controller bias to do so.
- Perform the same steps as you did when checking the P controller.
- Select one of the four traces and determine the damping ratio. If the damping ratio is not 4:1, just accept the result as is. Record all of your results and keep your trace. We will use the 'As-Found' tuning method to tweak your results in a later lab.