EECE 441: Control System Design Project

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The use of compressed air is widespread in industrial plants, and thus air compressors can frequently be found in process and manufacturing plants. Here we shall consider the control of a large air compressor, schematically depicted on Figure 1.

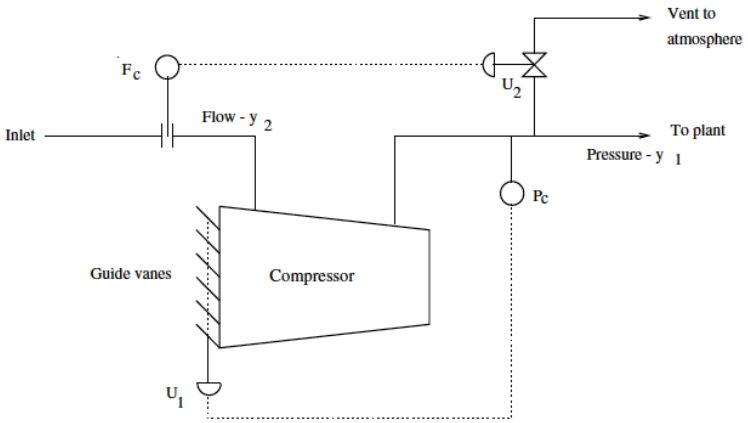

Figure 1: An air compressor

The outlet pressure is controlled by manipulating the guide vanes of the compressor. A blow-off valve is installed to prevent a surge.

When the blow-off valve is closed, the compressor is a single-input, single-output process that can be appropriately controlled using standard SISO control techniques.

When the blow-off valve opens, the compressor becomes a multivariable process with two inputs and two outputs. The manipulated variables (inputs) are the guide vane angle (u_1) and the position of the blow-off valve (u_2). The controlled variables (outputs) are the air pressure (y_1) and the air flowrate (y_2).

A linearized process model is given by:

$$\begin{bmatrix} Y_1(s) \\ Y_2(s) \end{bmatrix} = \begin{bmatrix} \frac{0.1133e^{-0.715s}}{1+4.48s+1.783s^2} & \frac{0.9222}{1+2.071s} \\ \frac{0.3378e^{-0.299s}}{1+1.09s+0.361s^2} & \frac{-0.321e^{-0.94s}}{1+2.463s+0.104s^2} \end{bmatrix} \begin{bmatrix} U_1(s) \\ U_2(s) \end{bmatrix} \tag{1}$$

1. Implement a computer simulation (Matlab or Simulink) of this system. Simulate 50 seconds of open-loop behaviour with a unit step change in guide vane angle at 5 seconds followed by a unit step change in blowoff valve opening at 25 seconds.
2. Assuming that the blow-off valve is closed, design and simulate a controller for air pressure (y_1) using the guide vanes angle (u_1) as manipulated variable. Note that the guide vanes angles is restricted to the $[-2.5\ 2.5]$ range. Your design should give fast response with minimal overshoot. Simulate 50 seconds of operation with a unit pressure setpoint step change at 5 seconds, followed by a step change of amplitude 0.1 in blowoff valve opening at 25 seconds. Note that the guide vanes angle u_1 is restricted to the $[-2.5\ 2.5]$ range.
3. Consider now u_2 as a measured disturbance. Is perfect feedforward compensation possible? Explain.
4. Design a realizable feedforward compensator to be added to the pressure loop you just designed. Simulate the previous scenario from 2) with your new setup. Discuss your results.

In your report, present detailed derivations of your various designs with justification of your choice of design technique and parameters. Show plots of your results as well as your code.