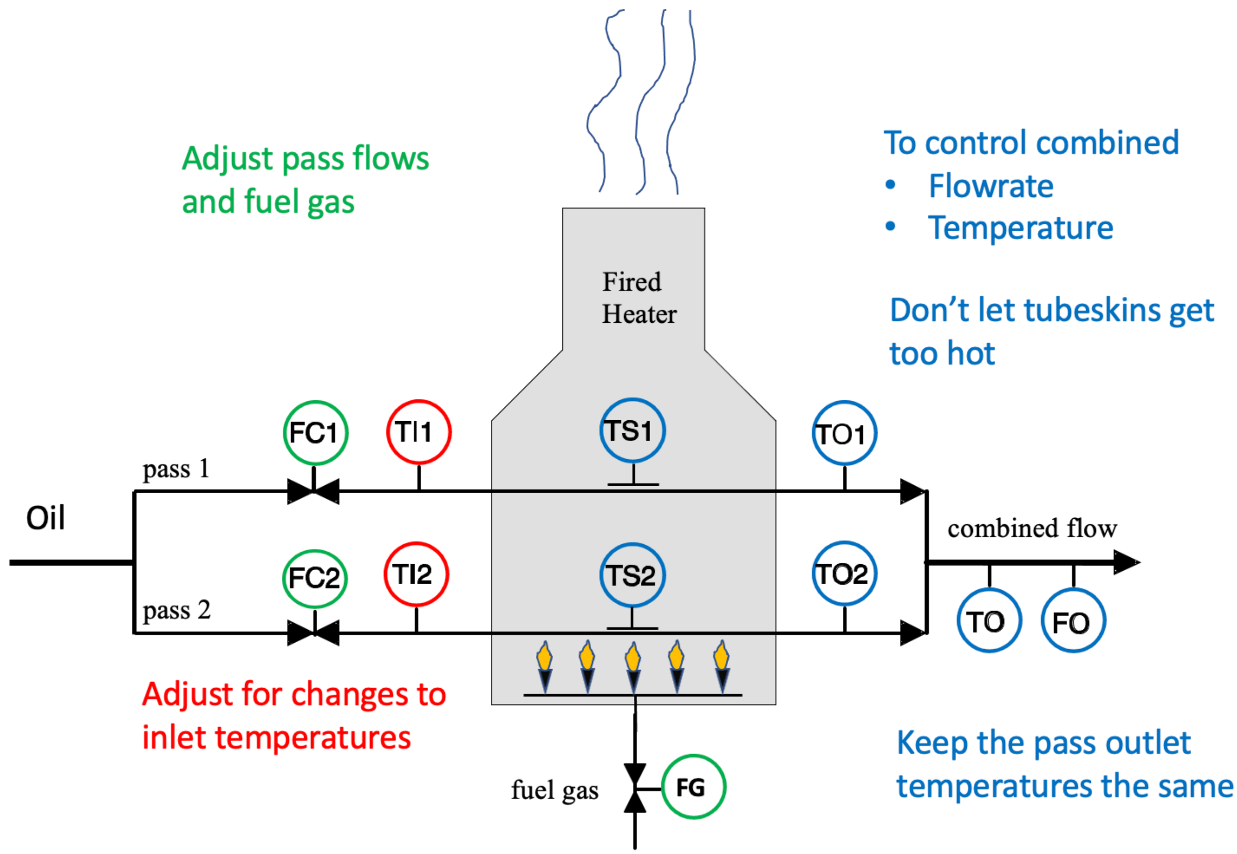
ChBE 4412 Design Project Phase 1

Fall 2021

Due Friday October 15

This case study was contributed by Dr. Tom Badgwell:



Resources

- Read “Model Predictive Control in Practice” by Badgwell and Qin, in the Reading Folder.
- Go through the “Fired Heater MPC Simulation Tutorial” in the Reading folder, including installation of the software.
- Watch the video by Tom Badgwell in the Design Project folder.

Note: You can engage with this material in any order that you choose, but all three are valuable resources for you.

Assignment

1. Construct a dynamic process model for the fired heater, using mass and energy balances. The model should include all of the CVs, MVs, and DVs. For this step, use only variables, not numerical values. State all of your assumptions. Comment on which parameters in your model are unknown, how you might estimate them, and whether or not the model is linear or nonlinear. Consider how you can capture the key phenomena, without creating a model that is overly complicated, especially given the limited information that is available to you.

2. The process is designed to operate at steady state with a total flowrate of 200 barrels per hour, with 100 BPH in pass 1 and 100 BPH in pass 2. The fuel gas flow rate is 95 MSCFH of natural gas, and the inlet temperature is 540°F. Perform this experiment using the software tool.

    a. What are the steady-state values of the CVs?
    b. How much heat is released from the burning of the fuel gas, assuming that the natural gas combustion is complete?
    c. What is the increase in enthalpy of the oil?
    d. What is the overall efficiency of the heating process?
    e. How can you use this steady-state information to estimate parameters in your model from Question 1?

3. Operating at steady state, the fuel gas is suddenly changed to 97 MSCFH (M = 1000). Perform this experiment using the software tool.
    a. What are the new steady-state values of the CVs?
    b. How fast do the CVs respond to this step change? (Note, time units are in minutes.)
    c. How can you use this new information to estimate additional parameters in your model from Question 1?

4. What additional experiments should you perform to gain more information for constructing your process model? Perform additional experiments and use this information for building your model.

5. Is the relationship between the inlet flow rate FC1 and the outlet temperature T0 linear or nonlinear, in the simulation tool? Perform numerical experiments and provide evidence for your conclusion.

6. How would you construct an empirical model for this process (instead of using mass and energy balances)? Construct an empirical model for the relationship between fuel gas and outlet temperature, using data from the simulation tool.