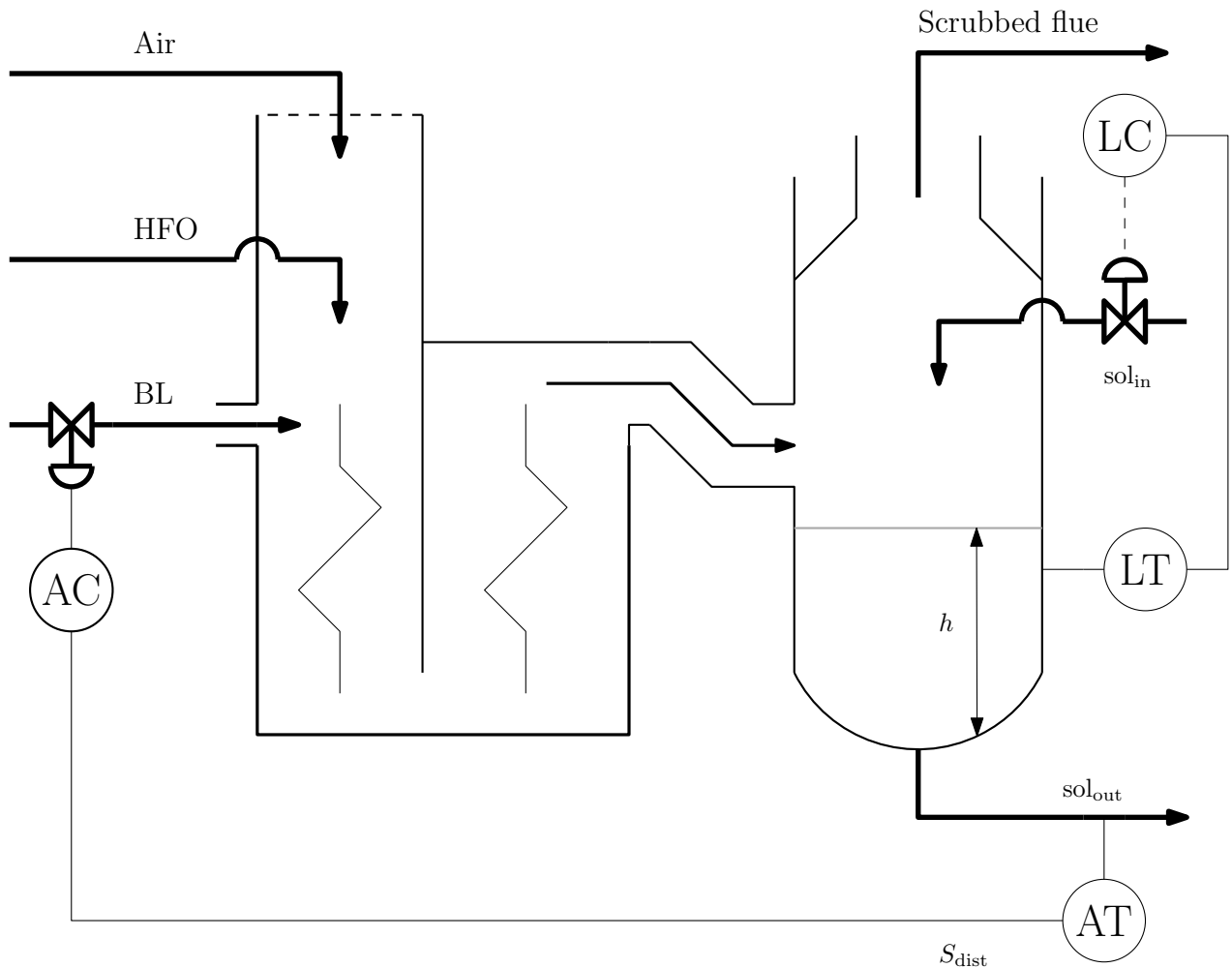


CPB 410 Project Part 3

June 2020 Time: 180 min

Boiler emissions control

You have been assigned a project as a process engineer. This project entails the modelling and control of two very large interconnected unit processes. You are responsible to add a suitable control loop to an existing simulation. The system below depicts two unit processes of the Sappi Saiccor plant. The two unit processes are a large boiler (30 m tall) and a scrubber.



The system's purpose is to combust two fuels (BL and HFO) in air to produce heat for the production of steam. The flue gas produced by the boiler is then stripped in an accompanying scrubber. The scrubber produces an acidic product called cooking acid.

The cooking acid composition needs to be accurately controlled for other processes in the plant to work optimally.

This document gives a summary of common abbreviations used in the attached simulation:

- HFO - Heavy fuel oil (burned in boiler)
- BL - Black liquor (burned in boiler)
- sol - Solvent (used to scrub flue)
- diss - Dissolved compound (indicates amount of solute in solvent)
- AC/AT - Composition controller/transmitter
- LC/LT - Level controller/transmitter

Tasks

1. The data supplied is very 'jaggedy/rough'. Write a single paragraph consisting of 2-3 sentences explaining why this occurs. Also mention two completely separate methods to avoid issues caused by this phenomenon. 5
2. This question is an **EXTRA CREDIT** question. You do not need to attempt this. In order for the simulation, and control thereof to be logical, we have decided to filter the data. `pandas.DataFrame.ewm` has really cool methods to filter an entire dataframe. Write a single code block (it doesn't have to be a function) that filters the dataset using the `ewm` function setting `alpha` to 0.01. We advise that you create a new dataframe in order to avoid multiple filtering passes. Continue the rest of the questions with this new filtered dataset. 5
3. In the attached notebook, an example simulation containing two proportional controllers is given. Write a paragraph in which you comment on the initial (first 0.1 hour) response of the system. Clearly state that the MV and SP of the compositional results plot were not identical. Explain why you think this occurred. Write another paragraph in which you comment on the different controllers as well as the influence of a single controller on a different control loop. 5
4. Perform a step test and fit a FOPDT model on the acid open loop (i.e. where the acid composition is changed by manipulating the black liquor flow). Assume that there is a five minute delay for the acid open-loop. Report your fitted parameters in a table, as well as plots to show your step response(s). 10

5. Using the Skogestad tuning method, implement continuous PI control on the acid loop. Ensure that the height control loop containing the proportional controller (`controller_h`) is still in the simulation. Simulate your controller with a reasonable set point change in acid composition. In the same simulation, implement a set point change on the existing height loop. Report the results in the form of the output graphs you generate. Comment on the results and each control loops ability to follow setpoint changes and disturbance changes where applicable. (30)

Full marks (50)

Total marks (55)