CH402 Capstone Design Problem
Atmospheric Distillation of Crude Oil

Overall Project Objectives

1) Enhanced understanding of unit and process operations.
2) Understanding IT infrastructure in a process plant.
3) Understanding basic controller configuration and operations in a process plant.
4) Understanding and appreciation of piping and instrumentation diagrams (P&IDs).
5) Enhanced understanding of process economics.
6) Enhanced understanding of ChemCAD.
7) Development of communication ability.
8) Enhanced understanding of safety issues confronting process engineers.

Problem Background

Simulation Solutions, Inc. is a company located in Shrewsbury, NJ, that makes process simulators. A process simulator is a virtual chemical plant designed to assist companies in training plant operators, engineers, and supervisors. The software interface is a representation of the actual control room that allows changes in control variables and shows a readout of the responses. The result is a "live" simulation of the plant. The latest beta test version of the software is a virtual petroleum refinery. The program contains control room and outside operator views of the plant. Some additional information about Simulation Solutions, Inc. can be found at: http://www.simulation-solutions.com.

The particular refinery that was modeled by Simulation Solutions is located in Bakersfield, CA. Bakersfield is located at the southern end of the San Joaquin Valley in South Central California. Kern County is home to 18 giant oil fields that have produced more than 100 million barrels of oil each, including four "super giants" that have produced over one billion barrels of oil. According to the San Joaquin Geological Survey, approximately 31,000 oil wells have been drilled in the county and 10% of U.S. oil production comes from this region. The refinery is one of 14 in California that can make the gasoline and diesel that meet the state's environmental regulations, particularly for low sulfur diesel. The refinery previously experienced a series of accidents that led to an overhaul of the safety procedures and to an intensive revamping of the safety protocols in the plant, including training protocols using the Simulation Solutions plant simulators. The Bakersfield refinery was formerly owned by Kern Oil & Refining, and was sold in 2008 to Flying J. The refinery is currently scheduled for a series of upgrades and expansions that will essentially double its production. You can visit the refinery website and view live webcam images at: http://www.bigwestca.com/bigwest/appmanager/bwoc/home?_nfpb=true&_pageLabel=flyingjPortal_portal_page_18

The simulated plant you will be operating is very new, and you will be conducting a "full" start up and shakedown of the plant. *This includes possible revisions of the start-up procedures.* The experiences you will go through are very similar to the issues that engineers and operators face when they start up a real plant. You will be faced with unknown technical questions, as well as possible incomplete procedures and diagrams. Your mission in this assignment is to develop a safe working start up procedure that will be used by operator and engineer trainees in the field. You will be provided with old help menus as well as a preliminary start up procedure, but may need to make modifications as you work your way through the plant.

The time requirements for this project are extensive, but you will have 13 lessons as well as the intervening time to complete it. For example, a minimum of 4-5 hours of simulator time is required for one complete pass through the simulator by a trained operator, which translates to 10-15 hours of actual time for your first run. You will also need to run the simulation multiple times to develop and improve your procedure, but the actual time should decrease substantially as you figure out what you are doing.

You will also have access to a demo FCC unit in Bartlett Hall Room 415 to assist you in visualizing the process. *This is important.* You will need to look at this and study it in order to understand the FCCU simulator. You are also encouraged to make liberal use of the internet in researching the process. There are many good websites with detailed descriptions.

General Tasks in the Design Project (To be completed by the end of the project):

1) Research hydrocarbon cracking chemistry and be able to provide an informed discussion.
2) Research the cracking process and know the basic functions of the major units in the process.
3) Familiarize yourself with the simulation software operating under design conditions. Explore the controllers and understand how each controller responds to disturbances. You will be asked to provide an I/O and a functions diagram of the process.
4) Modify the cold start procedure (provided) so that it is updated and current with the new simulation software.
5) Provide inspection protocols, including a mapping and log sheets, for all sensor, valve, and switch locations for the outside operator.
6) Provide a detailed design of the fractionator column using ChemCAD, and be prepared to offer the Flying J Oil Company a price quote for a new fractionator column for the expansion, including all support equipment, piping, pumps, and heat exchangers.
7) In lessons 38 and 39, you will give a PowerPoint presentation to the class.
8) In lesson 40, you will also be required to submit a written, updated procedure that works. This will comprise the formal report portion of your grade. As part of this grade, you will also be required to submit an electronic copy of your working start-up log file.

Requirements and Guidance on Design Problems for IPR-1:

IPRs are meant to ensure that you are making satisfactory progress toward the completion of the main tasks outlined above. IPRs are during class time, either AM or PM, or by appointment with me. Class time is otherwise reserved for informal group meetings and for project work. You are <u>required</u> to do 4 IPRs at approximately one-week intervals. IPRs are informal desk-side briefings, but there are submission requirements. You will receive written guidance for each. Failure to execute an IPR will result in a grade of zero for that portion of the grade. There are no re-dos allowed on IPRs.

VERY IMPORTANT: You will use the results of each IPR to perform the next IPR. They are cumulative in nature. Save your requirements on files on your share drive so that I can inspect your progress independently. <u>Bottom line</u>: If you meet the requirements of the IPRs, your report performance and preparation will be dramatically improved, and your grade will be considerably higher at the end of the semester.

Submission for IPR 1:

1) Develop chemistry background, including 1 <u>finished</u> PowerPoint slide of the cracking reaction and mechanism. Use reputable literature references. Wikipedia is considered a minimal level of performance (think rubric). SRI, Kirk-Othmer, McKetta's, and Ullman's are considered authoritative sources. Read and discuss the process economics as a group. Use this information to define your problem.
2) Develop process engineering background. You will be required to submit 1 <u>finished</u> slide of the I/O diagram for the process and 1 <u>finished</u> slide of the functions diagram. Use Example 4-2 in the text as a guide. Meet as a group and discuss this. Recall that I/O diagrams must include feed, product, and utility costs!
3) Required definitions: light-cycle oil, heavy cycle oil, crude oil, naphtha, fluid catalytic cracking, atmospheric distillation, vacuum distillation. Provide these definitions in <u>finished</u> PowerPoint slides, one definition per slide.
4) Develop general economic background for the problem. Again use reputable literature references. Read and discuss the process economics as a group. Use this information to define your problem. Again, SRI, Kirk-Othmer, McKetta's, and Ullman's are considered authoritative.
5) Present evidence to your instructor that you have made some progress on the start-up procedure. Remember that I am looking for multiple iterations.

Grading:

The design project is worth 400 points out of 1700 in the course, or approximately 23.5% of your grade. The written report is due on lesson 40 and is worth 200 points. The oral reports will be during lessons 39 and 40, and will be worth 100 points. You are also responsible for four (4) weekly IPRs, each worth 25 points.