A First Course on Kinetics and Reaction Engineering

Unit 11. Lesson Plan

Before Class

- Provide the redacted slides to the students and tell them to bring them to class
- Make arrangements so the students can run the simulators from Unit 11 in class (i. e. have them bring laptops or hold class in a computer lab where this is possible)

During Class

- Introduce today's topic and where it fits in the course (Slides 1 and 2)
- Review of Unit 11 (5 to 10 minutes)
  - Slides 3 through 5
- Ask whether the students have any questions from their pre-class preparation and answer them
  - Slide 6
- Learning Activity 11.1 (~10 minutes) - Use this activity to begin to teach them how to perform a qualitative analysis of a reactor
  - Slides 7 and 8:
    - Display slide 7 and go through first bullet item.
    - Walk them through the second bullet item, switching back and forth between slides 7 and 8. Stress the qualitative analysis e. g.: At the inlet the reactant C is high expect high rate, expect a lot of heat to be released. Now as you move a little distance into the reactor what happens to reactant concentration? to rate? to amount of heat released?
    - Back on slide 7, go through third bullet item emphasizing that you need to remove different amounts of heat at each point along the reactor. Ask how that can be done.
    - Go over last point quickly and then put up slide 8 and let them develop a plan for keeping the reactor isothermal; answer any questions they ask.
    - Have a few groups/individuals share their design; Let the class comment, and point out flaws in their design if you see them
    - Slide 9: Try to use their results to bring out the following points
      - If possible, using a thermal sink is the best approach; the sink is maintained at the desired temperature, so it's not possible to over-cool any part of the reactor
      - Still requires sufficiently rapid heat transfer where the heat release is greatest.
      - If a shell and tube configuration is proposed, point out that co-current feed is better than counter-current (i. e. the opposite of simple heat transfer)
      - Conclude by noting that this is why most commercial reactors are not isothermal; it is difficult to do so. Note that the model equations from Unit 11 won't apply if the reactor is not isothermal, so when we start modeling reactors for engineering purposes (instead of to process kinetics data), we'll need different models.

- Learning Activity (30 minutes) - divide the class into thirds, working alone or in groups, and assign one of the three simulators to each third of the class
  - Slide 10: Explain that they are going to perform a virtual stimulus-response experiment and analyze the data. Tell them that there are a few things to think about before they start the experiment (listed on the slide), and give them a few minutes to talk about it.
  - Slide 11: Call on individuals/groups to get their ideas about the two questions, then put up the slide and go over points on it
    - Note that when using an impulse stimulus with a CSTR, it is critical that the first sampling of the response be performed very quickly because the response is greatest at the start. If the sampling is delayed, the numerical integral of the response may be reduced substantially. This is discussed in the solution provided with this activity. You may wish to point it out before the students begin, or you may wish to let them discover it as they work.
    - If the students don't know how to run the simulator, tell them to read the user guide found under the help menu. Stress that once they have generated a data set in the window at the bottom of the simulator, they need to select it all and copy and paste it to another file so they have access to it for purposes of data workup.
    - Tell them to begin their experiment and then work up the data. Allow them to do so for most of the remaining class time. Circulate among them as they work answering questions, checking their work, etc.
  - When time is nearly up, put up Slide 12; tell them solution will be posted (or that completing the activity for all three simulators is their homework)
- Slide 13: show them what's next and how it relates to what's already been covered

After Class

- Provide the complete slides to the students.
- Provide the written solutions to the activities to the students or assign completion of the activity as homework and post the solutions after it has been turned in.