Date: March 18, 2016

From: G. Norval

To: 3rd Year Chemical Engineering Students and Instructors

The CHE311S/CHE333S/CHE334S Report

This note provides some definition regarding the final report.

Submission

The final report is to be submitted on, or by Tuesday April 8th, 2014, at 15:00. It is to be submitted by email only. The submission should be sent to Graeme.norval@utoronto.ca. I will combine the reports, and distribute these to the other course instructors.

The submission should have a pdf copy of the final report (no more than 20 pages of text – single space, double space at the paragraph) along with the computer files and drawings (the drawings should be pdf copies as well).

Format

The report should be written with single-spaced type, and double spacing at the end of a paragraph. An example of a good engineering technical report can be found at the Ontario Ministry of the Environment – file "5987e " – Sample Application Package for an Air and Noise Certificate of Approval. You will find the application forms, and a technical report. The writing style should follow that example – short, concise statements.

The report should start with an Introduction (short). Then, discuss each of the required topics in turn.

1) Overall balance: develop a mass and energy balance spreadsheet that also estimates equipment size (using linked spreadsheets)
2) Reactor: develop a spreadsheet that determines the size of an isothermal reactor, and develop a spreadsheet that determines the size of an adiabatic reactor
3) Distillation: develop the vapour-liquid equilibrium data and perform a McCabe-Thiele calculation for a distillation column; determine the size (dimensions, # of stages) of a distillation column
4) Response to Deviations: calculate the mass & energy balance for a feed at +/- 10°C from the design case, and determine the impact of this deviation on the process equipment (you can do this in ASPEN)
5) P&ID: develop a preliminary P&ID; discuss the impact of deviations on the system, and how these are to be controlled, including the control of upsets from a safety perspective. (the 7 deviations)

Content

When you discuss the reactor sizing (Height and Diameter and operating conditions), you need to comment on how you arrived at these conditions, as well as how you know the answer is reasonable. In part, this relates to a discussion about the volume of the system and whether it is reasonable. Also, you need to discuss the impact of the deviation (+/- 10°C) on the operation of the system.

The distillation column will have a sizing (height, diameter, number of stages, operating conditions). Again, you need to reflect on the impact of the deviation on the reactor – will the distillation column still work after the feed temperature changes?

The report needs to consider the 7 deviations from normal operations, which allows for identification of the consequence of process upsets, and also to identify means to mitigate the consequences. You need to reflect on the consequence of the deviation – what is the impact on the operation, and what can you do to mitigate that impact. Which parameters need to controlled within a narrow range, and which are you willing to allow more leeway?

This consideration leads to the P&ID development. There are 2 layers of control strategy for the P&ID. The first is the control layer – those items that you will measure, and those that you will measure and control. The control layer includes the items that you are willing to let the operators manipulate as they see fit. The second is the safety instrumented system layer. This layer is the automated response layer – at what point will you force the system to reduce temperature, or pressure – the operators can not override this layer.

Common Terminology

When we talk about size of a unit, we mean the dimensions (height, diameter, volume, and mass of catalyst) – these are all related.

When we talk about velocity in a unit, we mean the "empty vessel" velocity. Any solids that you put inside are randomly added, and the local velocity will vary, and it will be larger. But – the empty vessel velocity is constant throughout.

The bulk density of the catalyst can be assumed to be between 0.5 and 2 kg/L; the solids are more dense, but there is empty space between them.

When we talk about contact time and space velocity, we will use the Gas Hourly Space Velocity (Volumetric Gas flowrate (m^3/hr @T&P) divided by the empty vessel volume m^3), which gives a GHSV (1/hr). If you have a mass of catalyst, we use the weight Hourly Space Velocity WHSV = Mass Feed (kg/hr) divided by mass of catalyst (kg). Typical values are between 0.1 and 5 hr^{-1}.