Continuous Distillation

Distillation is a common method of separating and purifying liquids. Its operation is based on differences in boiling points between components of a liquid mixture. The more volatile components move up the column and the less volatile ones move down. In this experiment, you will use distillation to separate isopropanol and 2-butanol by operating the distillation column at steady-state conditions.

System Overview

Schematics of the Continuous Distillation system is shown in Figure 1. The distillation is performed using the West Column (WC) containing 24 bubble cap trays and spanning the first two floors of the lab. Other key components of the system are:

- Steam-heated reboiler (located on the 1st floor)
- Distillate and Bottoms tanks T2 and T3 (located on the 1st floor)
- Water-cooled condenser and standpipe, in which distillate is held up after being condensed (located on the 2nd floor)
- Feed tank T5 (located on the 3rd floor)

The distillation column is controlled by a distributed control system DeltaV with operator stations located in the control room on the 2nd floor of the lab. Compositions of the feed and the products are determined using a Gas Chromatograph (GC) which is also located in the control room.

Figure 1. Diagram of the continuous distillation system. Product lines are shown in black (liquid) and gray (vapor). Steam and steam condensate lines are shown in red and water lines are shown in blue.
Degrees of Freedom

The main independent control variables available are

- Reflux ratio
- Feed tray
- Flow rate of steam to the reboiler
- Flow rate of water to the condenser

You should carefully choose operating conditions before running an experiment. Remember that it takes a long time (30-40 minutes) for the system to reach a steady-state, so choosing inadequate parameters will result in wasting a lot of time. One of the main goals of the 1st day of experiments is to collect the data necessary to choose sensible experimental conditions for the 2nd day of experiments.

Objectives

1. Determine the overall efficiency of the column.
2. Determine local efficiency of individual trays.
3. Investigate effect of reflux ratio on the product composition.
5. Optional: investigate effect on changing flow rates of steam and cooling water.
6. Optional: obtain stage by stage temperature and composition profiles.

Schedule

Week 1

- Run the column at total reflux and determine the overall and local efficiencies. For this, you should measure composition of the top and bottom products, as well as of samples taken from individual trays.
- Calibrate the GC. It is recommended to work on calibration while the distillation column is warming up.
- Investigate dependence of the reflux flow rate on the steam flow rate.
- Develop an experimental plan for Week 2.

Week 2

- Perform distillation at finite reflux using reflux ratios and steam flow rates determined from your analysis of the data from Week 1.