Problem Set 4: Binary Distillation

Note: Use a graphical stage-to-stage calculation to solve the following problems. You may assume in the solution of these problems that an optimal feed plate location is used.

1. A distillation column is to be designed to separate methanol and water continuously. The feed contains 40 mol/s methanol and 60 mol/s water and is saturated liquid. The column pressure is 101.3 kPa (1 atm), for which the binary equilibrium data in terms of the methanol composition (in mol %) at equilibrium are as follows:

Liquid	Vapor
2.0	13.4
6.0	30.4
10.0	41.8
20.0	57.9
30.0	66.5
40.0	72.9
50.0	77.9
60.0	82.5
70.0	87.0
80.0	91.5
90.0	95.3
95.0	97.9

The feed is to be introduced at the optimal location to yield the minimum number of stages. 95 mole percent of the methanol is to be recovered in a liquid distillate consisting of 98 mol-% methanol. The reflux is to be saturated liquid with a flow rate 1.25 times the minimum reflux rate which would correspond to an infinite number of stages. Assuming constant molar overflow, find the number of equilibrium stages required in the column.

2. An existing column providing seven equilibrium stages plus a partial reboiler is being considered for use in the methanol-water distillation described in Problem 1. The feed is introduced at the optimal location. If the column will be operated at whatever reflux ratio is required to produce both the purity and recovery fraction of methanol indicated in Problem 1, what will the necessary rate of vapor production in the reboiler be in moles per second? Also, after solving this problem with a graphical stage-to-stage calculation, confirm your result by performing a simulation using either COCO/ChemSep or ASPEN.

3. Suppose that the allowable vapor rate in the column described in Problem 2 is limited by the reboiler capacity to 90 mol/s. For the given 100 mol/s of feed, what is the maximum fraction of the methanol fed to the column that can be recovered at a purity of 98 mole percent?

4. One alternative for increasing the capacity of the column in Problems 2 and 3 is to install a feed preheater which will partially vaporize the feed. If the column is to have a vapor-generation rate of 90 mol/s in the reboiler, and if the feed can be introduced on any stage, what percentage of the feed must be vaporized in order for 95 percent of the methanol to be recoverable at 98 mole percent purity?