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Separation Processes

Spring 2004

QUIZ 1

1. (40) A three component mixture containing 30 percent A, 30 percent B and 40 percent C is to be run through a continuous steady-state flash unit. The exit pressure from the flash unit will be one atmosphere.

A is non-condensible (i.e., vapor pressure approaches infinity) and C is non-volatile (i.e., vapor pressure approaches zero). The vapor pressure of B is given by:

$$\ln(P_B) = 10.465 - 3890/T$$

where P_B is in atmospheres and T is in Kelvins.

a). If the unit is operated so the flowrates of liquid and vapor leaving the unit are equal, determine the compositions of the outlet streams and the outlet temperature.

b). If the unit is operated so that 30 percent of the B in the feed leaves the unit in the vapor stream, determine the compositions of the outlet streams and the outlet temperature.

2. (60) We have a very dilute solution of a non-volatile polymer in benzene. We wish to transfer the polymer to a toluene solvent. One proposed scheme is shown in Figure 1. A continuous steady-state distillation column will be used. The benzene-polymer solution will be fed at a rate of 100 mol/hr to the top tray of the column, along with some reflux from the condenser. The toluene will be fed at a rate of 100 mol/hr to the stillpot at the bottom of the column. Both feeds are saturated liquids. The polymer, being non-volatile, will flow down the column in the liquid stream and leave the column in the bottom product..

Liquid-vapor equilibrium data for the benzene-toluene system are given in Figure 2. The concentration of the non-volatile polymer is sufficiently low that its presence can be neglected in the distillation analysis.

We wish to make a distillate product containing 95 mol percent benzene (and no polymer) and a bottom product containing 5 mol percent benzene (and all of the polymer).

The column is to be operated at a reflux ratio of 0.1 (i.e., 0.1D mols/hr of the condensed vapor leaving the condenser will be returned to the top plate of the column along with the benzene feed).

a) Determine the distillate and bottom product rates, D and B.

b). Determine the flow rates of the liquid and vapor streams in the column.

c). Derive the material balance relating the concentrations of passing liquid and vapor streams in the column. Plot that material balance on Figure 2.

d). Determine the number of theoretical stages required to make the separation. (Extreme precision not required.)

e). Could the number of stages required be reduced by increasing the reflux ratio? Think carefully about this specific separation before answering. Discuss briefly.

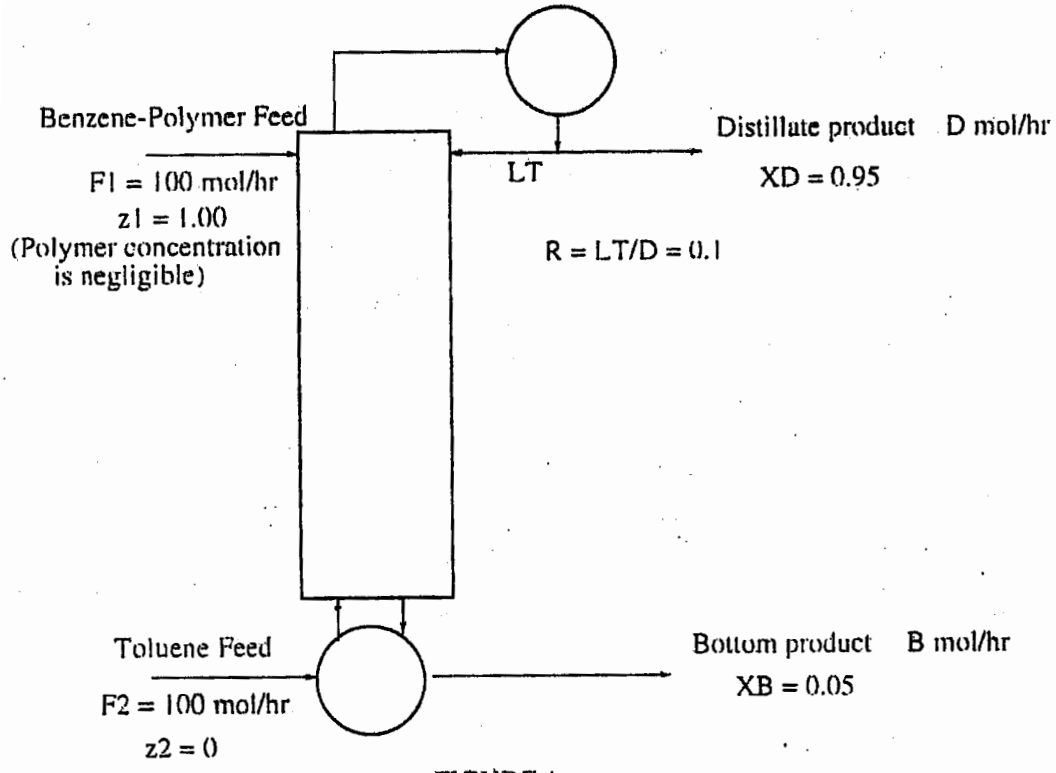

FIGURE 1