

Figure 7-2. Total liquid and vapor flow rates. Simulation for distillation of benzene-toluene-cumene. Desire 99% recovery of benzene. Feed is 0.233 mole frac benzene, 0.333 mole frac toluene, and 0.434 mole frac cumene and is a saturated liquid.  $F = 1.0$  kg mole/hr. Feed stage is number 10 above the partial reboiler, and there are 19 equilibrium stages plus a partial reboiler. A total condenser is used.  $p = 101.3$  kPa. Relative volatilities:  $\alpha_{\text{ben}} = 2.25$ ,  $\alpha_{\text{tol}} = 1.0$ ,  $\alpha_{\text{cum}} = 0.21$ .

The compositions in the column are much more complex. To study these, we will first look at two computer simulations for the distillation of benzene, toluene, and cumene in a column with 20 equilibrium contacts. The total flow and temperature profiles for this simulation are given in Figures 7-2 and 7-3, respectively. With a specified 99% recovery of benzene in the distillate, the liquid mole fractions are shown in Figure 7-4.

Figure 7-3. Temperature profile for benzene-toluene-cumene distillation. Same problem as in Figures 7-2 and 7-4.

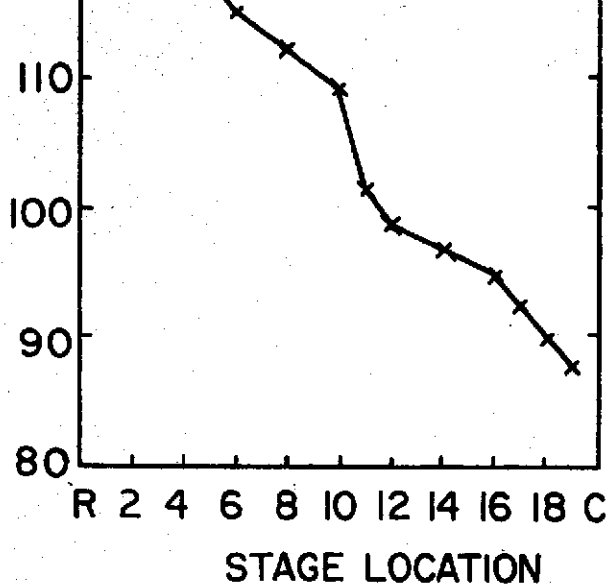
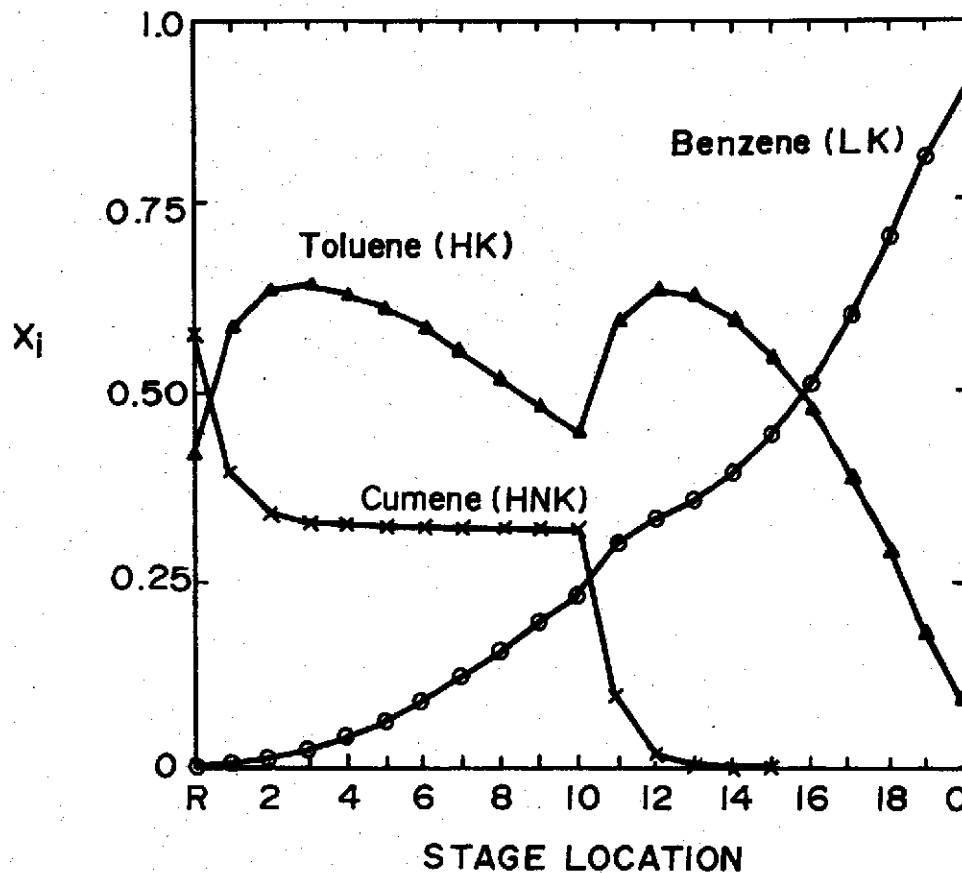


Figure 7-4. Liquid-phase composition profiles for distillation of benzene-toluene-cumene. Same conditions as Figures 7-2 and 7-3 for nonconstant molal overflow. Benzene is the light key, and toluene is the heavy key. Stage 10 is the feed stage.



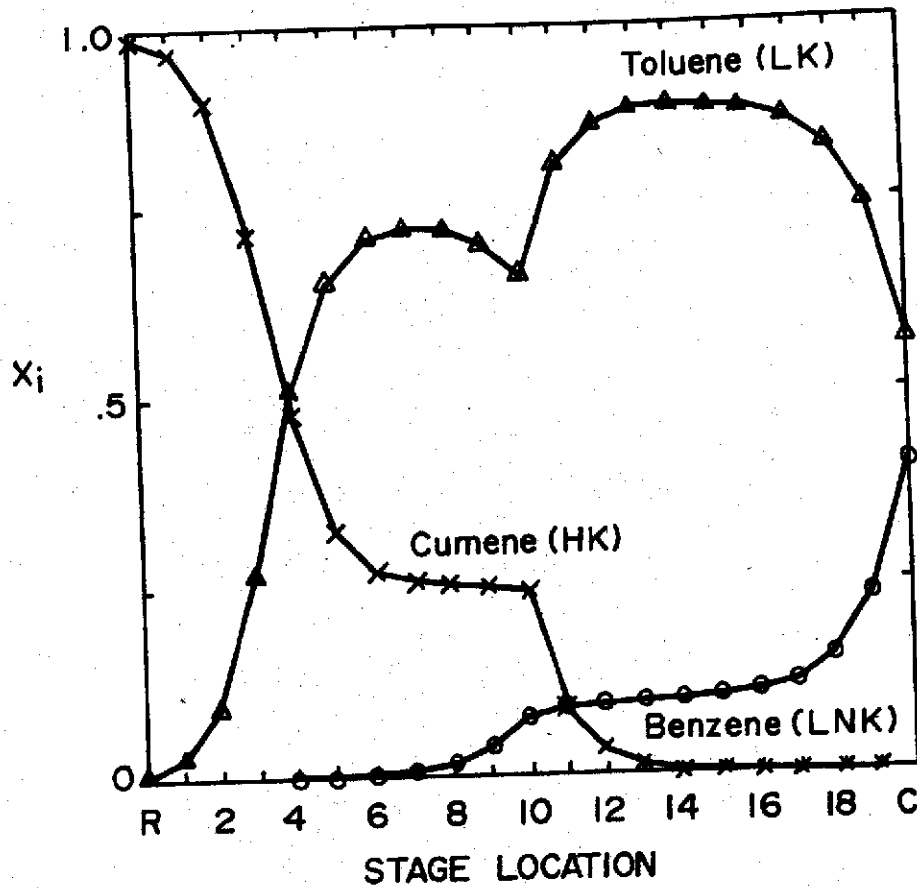


Figure 7-5. Liquid phase composition profiles for distillation of benzene (LNK), toluene (LK), and cumene (HK). Same problem as in Figures 7-2 to 7-4 except that a 99% recovery of toluene in the distillate is specified.

light non-key, the light key (benzene) has no maxima. It is informative to redo the example of Figures 7-2 to 7-4 with everything the same except for specifying 99% recovery of toluene in the distillate. Now toluene is the light key, cumene the heavy key and benzene a light non-key. The result achieved here is shown in Figure 7-5. This figure can also be explained qualitatively in terms of the distillation of binary pairs (see Problem 7-A14). Note that with no heavy non-keys, the heavy key concentration does not have any maxima.

What happens for a four-component distillation if there are light and heavy keys and light and heavy non-keys present? Since there is a light non-key, we would expect the light key curve to show maxima; and since there is a heavy non-key, we would expect maxima in the heavy key curve. This is the case shown in Figure 7-6 for the

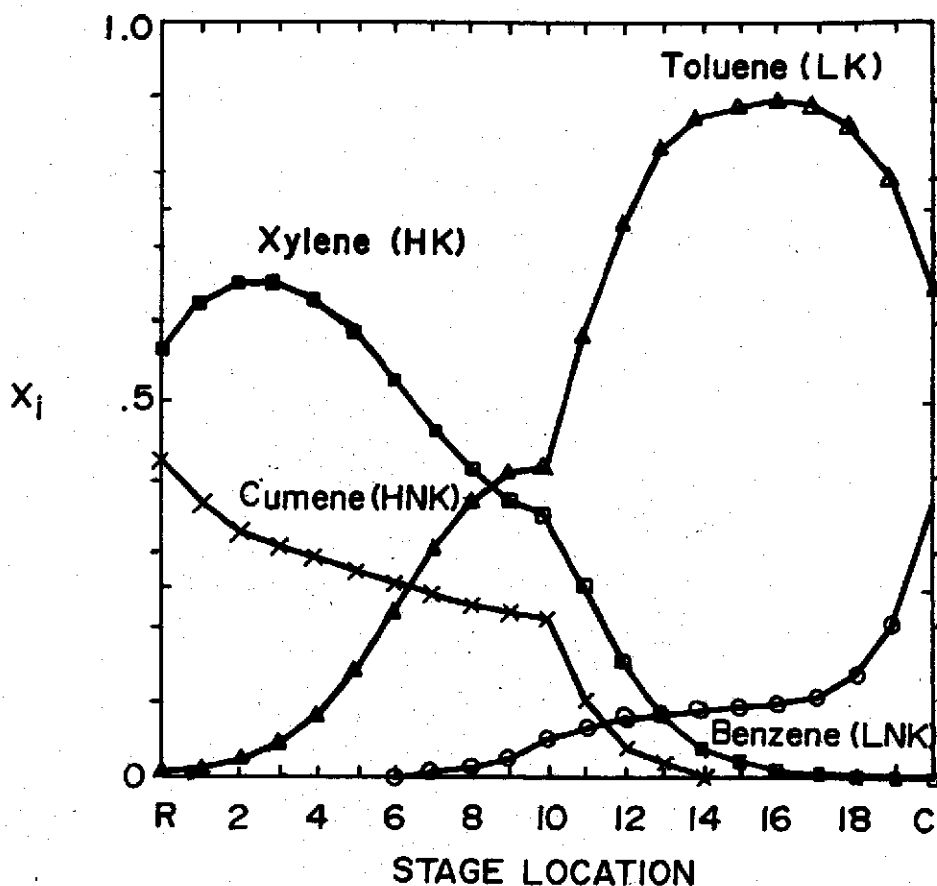


Figure 7-6. Liquid composition profiles for distillation of benzene (LNK), toluene (LK), xylene (HK), and cumene (HNK). Feed is 0.125 benzene, 0.225 toluene, 0.375 xylene, and 0.275 cumene. 99% recovery toluene in distillate. Relative volatilities:  $\alpha_{ben} = 2.25$ ,  $\alpha_{tol} = 1.0$ ,  $\alpha_{xy} = 0.33$ ,  $\alpha_{cum} = 0.21$ .

1. In multicomponent distillation the key component concentrations can have maxima.
2. The non-keys usually do *not* distribute. That is, heavy non-keys usually appear only in the bottoms, and light non-keys only in the distillate.
3. The non-keys go through a plateau region of nearly constant composition.
4. All components must be present at the feed stage, but at that

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2. The non-keys usually do *not* distribute. That is, heavy non-keys usually appear only in the bottoms, and light non-keys only in the distillate.
3. The non-keys go through a plateau region of nearly constant composition.
4. All components must be present at the feed stage, but at that stage the primary distillation changes. Thus discontinuities occur at the feed stage.

Understanding the differences between binary and multicomponent distillation will be helpful when you are doing calculations for multicomponent distillation.