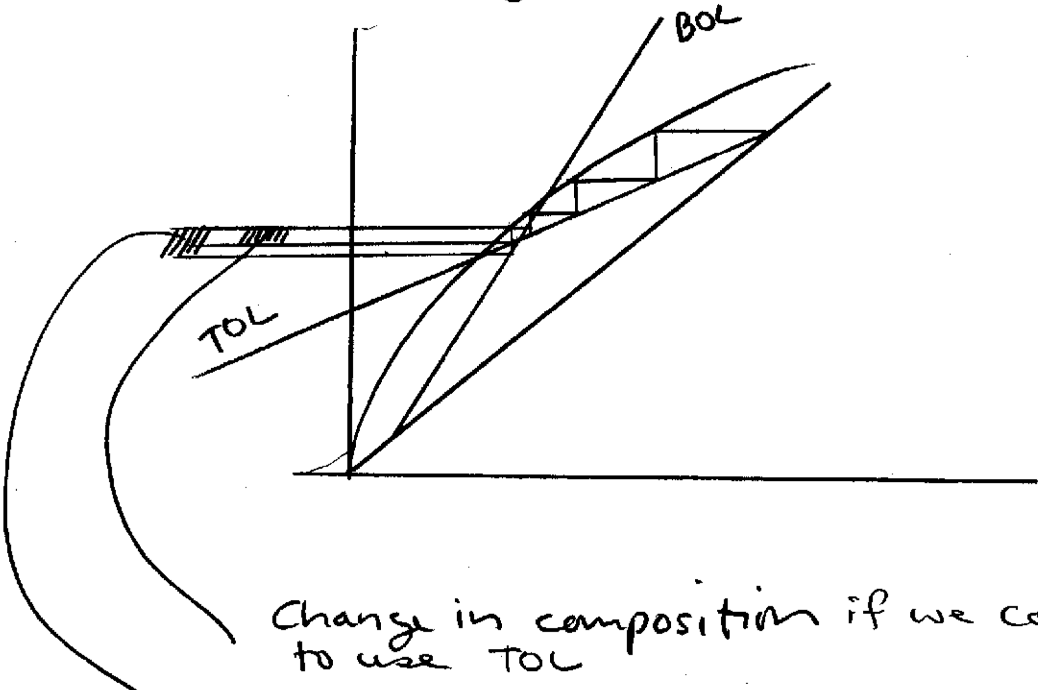
4-11

Non optimal feed stage location requires additional stages to effect the same separation (get same products).

The reason for this is that the slope of the operating line which will be used is obviously different, hence the distance from the equilibrium curve to the operating line will be different.



Change in composition if we continue to use TOL

Change in composition if we switch to BOL.

Figure 7.9 (p 370) [4-11a] shows this in more detail.

When numbering top-down and the feed line crosses the TOL, BOL between stages m and m+1, the feed should be assigned to the m+1 th stage.

4-12

Limiting conditions

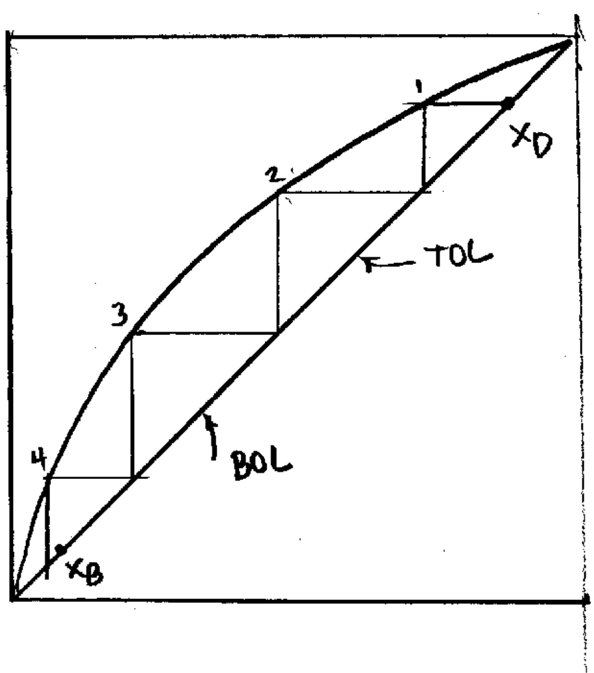
(A) Minimum number of stages (total reflux). See Figure 7.10(a) {4-12a}

If a column is charged and operated without removing the product streams the reflux ratio and boilup ratio become infinite.

The rate at which vapor moves up the column and liquid flowing down the column are identical.

$\frac{L}{V}$ and $\frac{\bar{L}}{\bar{V}}$ are 1.0

$\therefore$ the slope of TOC & BOC are 1.0



4-13

(b) Minimum reflux ratio (Figure 7.10 b)
{4-12a}

Under these conditions, the tradeoff between L/D and N_{stages} reaches the extreme case $(L/D)_{min}$ w/ $N_{stages} \rightarrow \infty$

This corresponds to allowing the TOL-BOL intersection coincident with the FOL - EE line.

Figure 7.12a (p372) {4-13a} shows this.

When systems have significant non-idealities this L/D_{min} may not be able to be reached due to a point of "pinch" due to the curvature of the EE-line.

Figure 7.12 b.

A related concept is perfect separation where $x_B = 0 \quad x_D = 1.0$

Figure 7.11c.

For nearly ideal systems w/ const α

$$R_{min\,(perfect)} = \frac{1}{z_F(\alpha-1)}$$

4-14 Reading for student

- column operating pressure 374
- subcooled reflux 376
- reboiler type 380
- Condenser and reboiler duties 381
  (note definition of "Duty")
- Feed Preheat 382
- optimum reflux ratio 383

Large Number of Stages.

See graph showing log plots
(x_B end) (x_D end)
Figure 7.23 (a) (b) [4-14a]

Overall Column Efficiencies.

Often the various stages in a column do not achieve equilibrium and additional stages are required above $N_{theoretical}$.

This problem generally does not include partial reboilers and partial condensers which act as true equilibrium stages.

Reasons for failing to reach equilibrium can include

- Maldistribution of vapor or liquid

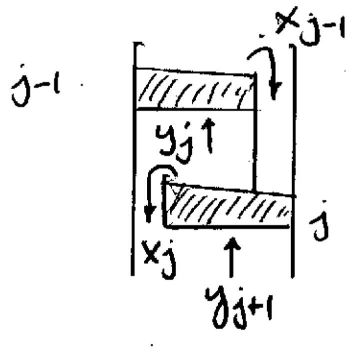
4-15

- insufficient contact time (insufficient liquid depth, bubbles too large, column diameter too small)
- weeping
- misting
- excessive viscosity (mass transfer)
- etc.

A poor approach is to assign a column efficiency

$$E_{overall} = \frac{N_{eq,\,theoretical}}{N_{actual,\,in\,column}}$$

A better approach to deal with these problems is to use Murphree Stage Efficiencies (MSE).



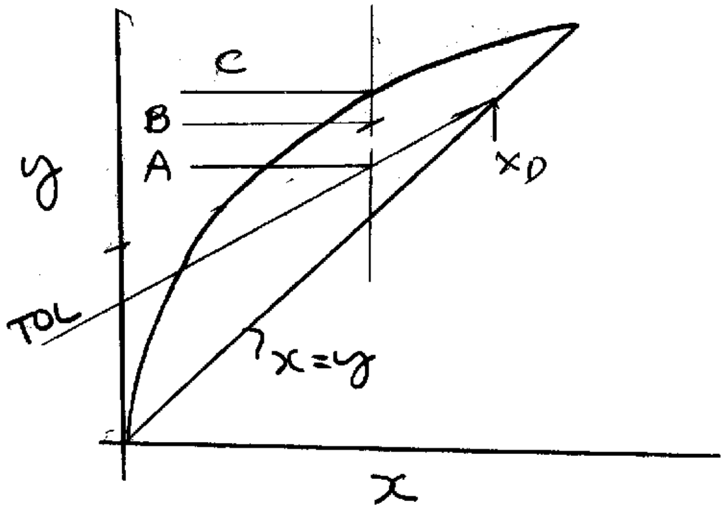
Murphree Vapor Efficiency

$$E_V = \frac{\text{actual change in vapor composition}}{\text{theoretical change if equil attained}}.$$

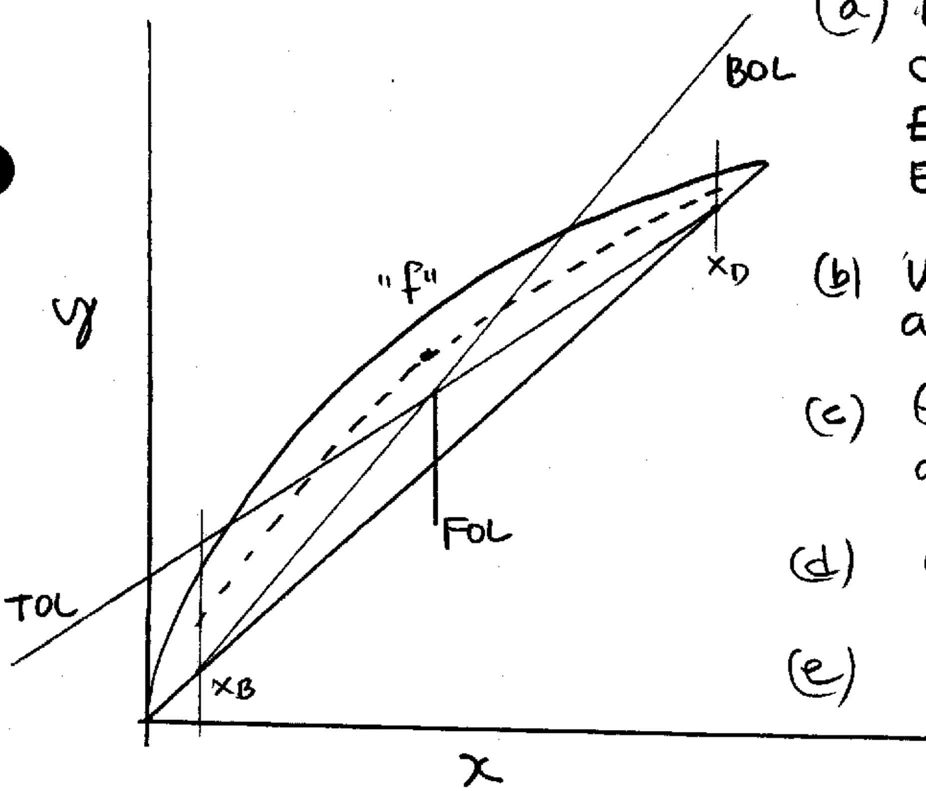
$$\therefore E_V = \frac{y_j - y_{j+1}}{y_j^* - y_{j+1}}$$

where $y_j^* = EE(x_j)$

4-16



$\therefore E_V = \dfrac{\overline{AB}}{\overline{AC}}$



To construct

(a) Locate fractional distance between EE & TOL or EE & BOL.

(b) Use reasonable accuracy

(c) Expect discontinuity at "f"

(d) Employ from $x_B < x < x_D$

(e) Step for PC & PR is 100%

Also see Figure 7.25 (p387) [4-15a]