**Separation Process II Tutorial: Ponchon-Savarit**

**Ponchot Savarit Method: Distillation column, binary mixture**

1000 kg/hr of a mixture containing 42 mole percent heptane and 58 mole percent ethyl benzene is to be fractionated to a distillate containing 97 mole percent heptane and a residue containing 99 mole percent ethyl benzene using a total condenser and feed at its saturated liquid condition. The enthalpy-concentration data for the heptane-ethyl benzene at 1 atm pressure are as follows:

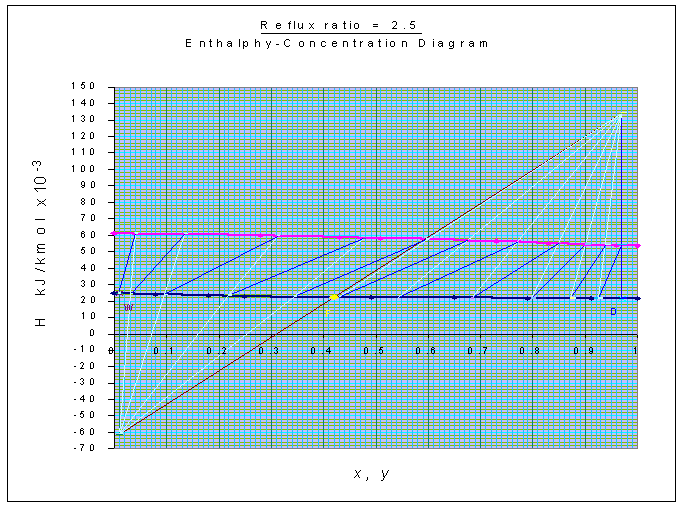
|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| xheptane | 0 | 0.08 | 0.18 | 0.25 | 0.49 | 0.65 | 0.79 | 0.91 | 1.0 |
| yheptane | 0 | 0.28 | 0.43 | 0.51 | 0.73 | 0.83 | 0.90 | 0.96 | 1.0 |
| Hl (kJ/kmol) x 10-3 | 24.3 | 24.1 | 23.2 | 22.8 | 22.05 | 21.75 | 21.7 | 21.6 | 21.4 |
| Hv (kJ/kmol) x 10-3 | 61.2 | 59.6 | 58.5 | 58.1 | 56.5 | 55.2 | 54.4 | 53.8 | 53.3 |

Suppose you want to develop a module for computation of number of stages and minimum reflux ratio using MATLAB. In order to perform this, carry out the first steps as follows.

1. MATLAB: Draw the equilibrium curve in figure (1).
2. MATLAB: Draw the enthalpy concentration diagram for the mixture to be separated in figure (2).
3. Pen and paper: Write the material balance across the continuous distillation column and calculate the compositions of the feed, distillate and bottom products.
4. MATLAB: Using plot function, locate these compositions on the enthalpy-concentration diagram through square (for feed position) and triangles (distillate and bottom product, D point and W point).
5. MATLAB: Assuming reflux ratio = 2.5, and locate the rectifying section difference point as ΔR. Show the line joining point xD and ΔR. Show the point y1 is the intersection point of line joining point xD and ΔR and HV-y curve.
6. Locate the stripping section difference point Δs. The point Δs is to be located at a point where the line from ΔR through xF intersects the xB composition coordinate.
7. Show the feed line in the graph.

Calculate the following using graphical method:

1. Number of stages in rectification section at reflux ratio of 2.5 using Panchan Savarit method.
2. Plot a heatmap of the concentration profile of heptane and ethyl benzene [in vapour phase and distillation phase along the length of the distillation column [ with stage numbers].
3. Calculate the liquid flow rate and vapour flow rate at various stages for reflux ratio =2.5 and 2.3.



Coding Hints and functions:

**Syms, EquationsToMatrix**

syms x y z

eqns = [x+y-2\*z == 0,

x+y+z == 1,

2\*y-z == -5];

[A,b] = equationsToMatrix(eqns)

vars = symvar(eqns)

A =

[ 1, 1, -2]

[ 1, 1, 1]

[ 0, 2, -1]

b =

0

1

-5

vars =

[ x, y, z]

**Polyfit**

[p = polyfit(x,y,n)](https://in.mathworks.com/help/matlab/ref/polyfit.html#d122e1001702)

[[p,S] = polyfit(x,y,n)](https://in.mathworks.com/help/matlab/ref/polyfit.html#d122e1001742)

[[p,S,mu] = polyfit(x,y,n)](https://in.mathworks.com/help/matlab/ref/polyfit.html#d122e1001766)

y = polyval(p,x)

y = polyval(p,x,[],mu)

[y,delta] = polyval(p,x,S)

[y,delta] = polyval(p,x,S,mu)

Fitting straight line with conccnetration enthalpy curves:

Hl\_p = polyfit(x,Hl,1);

Hv\_p = polyfit(y,Hv,1);

Hw = polyval(Hl\_p,xw);

Hd = polyval(Hl\_p,xd);

Hv1 = polyval(Hv\_p,xd);

Hf = polyval(Hl\_p,xf);

Drawing stages

while(x\_int > xw)

xc = fzero('eqb1',0.5);

yc = polyval(Hl\_p,xc);

if (x\_int >= x\_int\_f)

slope = (yc-Qd\_dash)/(xc-xd);

intercept = -slope\*xd+Qd\_dash;

line = polyfit([xc xd],[yc Qd\_dash],1);

y\_line = polyval(line,x);

x\_int = interp1((y\_line-Hv),x,0);

y\_int = polyval(line,x\_int);

if (slope >= slope\_F)

plot(x\_int,y\_int)

plot([xc xd], [yc Qd\_dash])

plot(xc,yc,'-\*r')

plot(x\_int,y\_int,'-\*r')

stage = stage+1;

li(stage)=x\_int;

va(stage)=interp1(x, y, x\_int);

liq(stage)=1-x\_int;

vap(stage)=1-interp1(x, y, x\_int);

end

Initialization:

yg = xd;

xc = xd;

yc = xd;

xp = xc;

yp = xc;

x\_int = xd;

Stages plotting and storing concentration : Hints:

if (x\_int >=xfeed)

plot(x\_int,y\_int,'-\*r')

plot([xc xd], [yc Qd\_dash])

plot(xc,yc,'-\*r')

stage = stage+1;

li(stage)=x\_int;

va(stage)=interp1(x, y, x\_int);

liq(stage)=1-x\_int;

vap(stage)=1-interp1(x, y, x\_int);

end

yg = x\_int;

xp = xc;

yp = yc;