HW9_3

April 15, 2022

1 Homework 9

1.1 Problem 3

Determine lowest benzene composition in the bottoms given certain conditions.

15 trays at 20% efficiency is equivalent to 3 equilibrium stages.

The minimum composition in the bottoms is achieved at total reflux where the operating line is $y = x$.

1.2 Problem 3.1

Total condensers and total reboilers do not count as equilibrium stages so the column still only has 3 equilibrium stages.

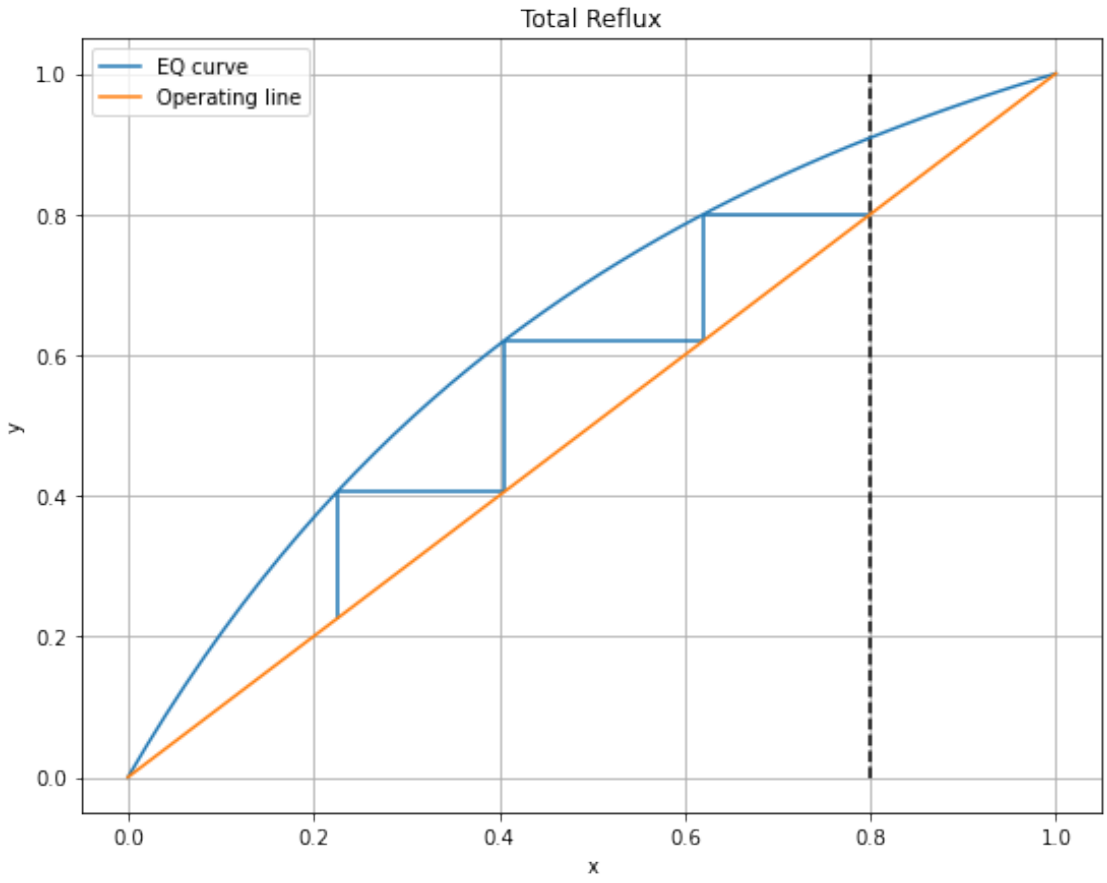
[ ]:
```
import pandas as pd
from scipy.interpolate import interp1d
import matplotlib.pyplot as plt
```

[ ]:
```
file = pd.read_csv('Txy.csv')                    #data from csv
temp = file['T'].values
x = file['x'].values
y = file['y'].values

xInterp = interp1d(y,x)                          #interpolated data
yInterp = interp1d(x,y)

z = .5                                           #feed comp molfrac
F = 45                                           #feed kg/hr
xD = .8                                         #molfrac distil
```

[ ]:
```
plt.figure(figsize = (9,7))
plt.plot(x,y,label='EQ curve')
plt.plot(x,x,label='Operating line')
plt.vlines(xD,0,1,'k','--')

x1 = xD
y1 = xD
x2 = xInterp(y1)
```

```
y2 = x2
x3 = xInterp(y2)
y3 = x3
x4 = xInterp(y3)
y4 = x4

plt.hlines(y1,x1,x2)
plt.vlines(x2,y1,y2)
plt.hlines(y2,x2,x3)
plt.vlines(x3,y2,y3)
plt.hlines(y3,x3,x4)
plt.vlines(x4,y3,y4)


plt.grid()
plt.title('Total Reflux')
plt.xlabel('x')
plt.ylabel('y')
plt.legend()
;
print(x4)
```

```
0.2252455521901447
```



The minimum composition in the bottoms with a total reboiler and total condenser is $x_B = 0.225$.

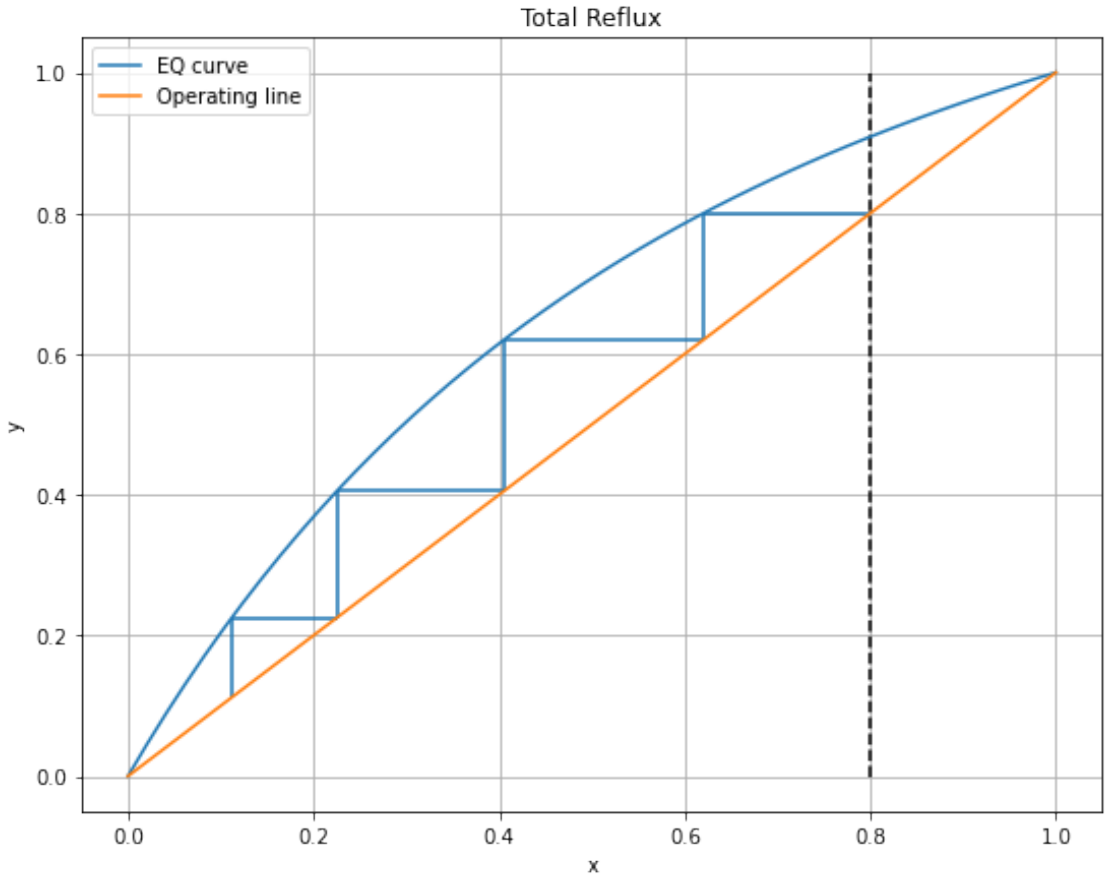
1.3 Problem 3.2

With a partial condenser and total reboiler, there is one added equilibrium stage to the column so $N = 4$.

[ ]:
```
plt.figure(figsize = (9,7))
plt.plot(x,y,label='EQ curve')
plt.plot(x,x,label='Operating line')
plt.vlines(xD,0,1,'k','--')

x1 = xD
y1 = xD
x2 = xInterp(y1)
y2 = x2
x3 = xInterp(y2)
y3 = x3
x4 = xInterp(y3)
y4 = x4
```

```
x5 = xInterp(y4)
y5 = x5

plt.hlines(y1,x1,x2)
plt.vlines(x2,y1,y2)
plt.hlines(y2,x2,x3)
plt.vlines(x3,y2,y3)
plt.hlines(y3,x3,x4)
plt.vlines(x4,y3,y4)
plt.hlines(y4,x4,x5)
plt.vlines(x5,y4,y5)

plt.grid()
plt.title('Total Reflux')
plt.xlabel('x')
plt.ylabel('y')
plt.legend()
;
print(x5)
```

```
0.11198062383404807
```



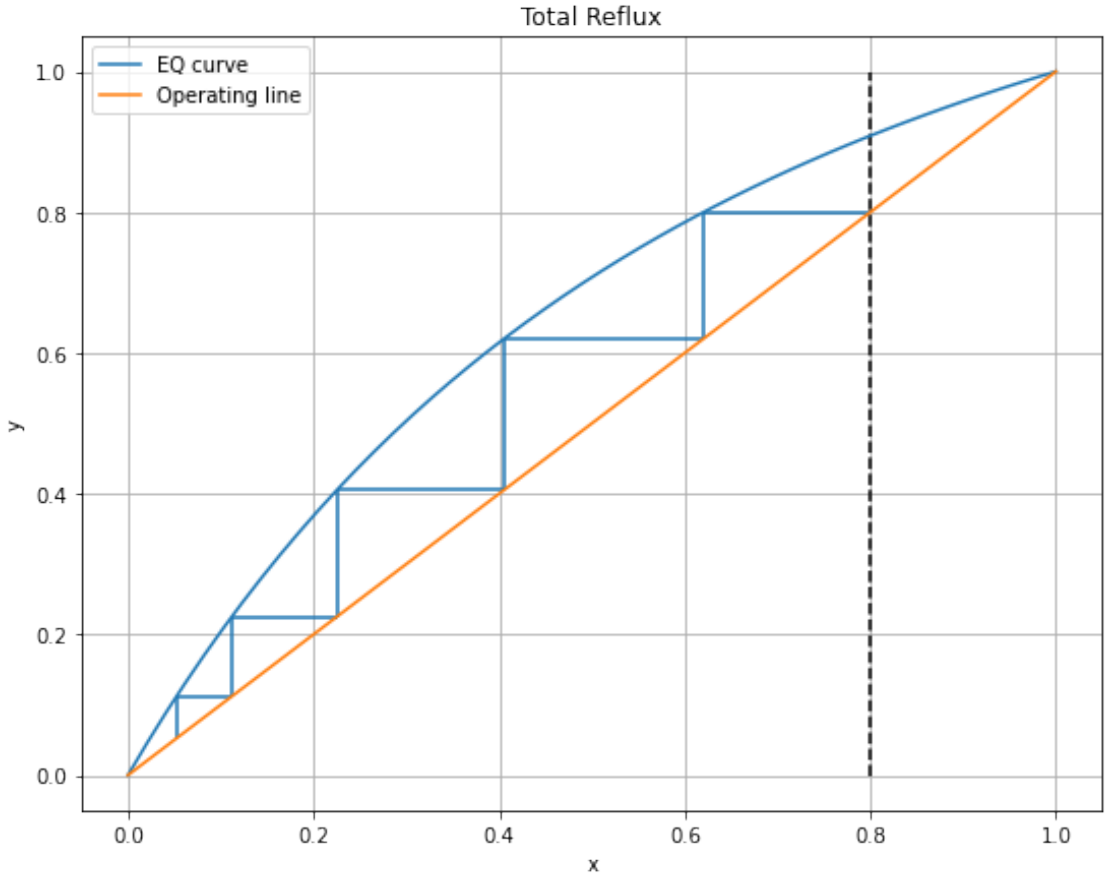
The minimum composition with a partial condenser and total reboiler is $x_B = 0.112$.

1.4 Problem 3.3

With a partial reboiler and partial condenser, the column has two added equilibrium stages so $N = 5$.

[ ]:
```
plt.figure(figsize = (9,7))
plt.plot(x,y,label='EQ curve')
plt.plot(x,x,label='Operating line')
plt.vlines(xD,0,1,'k','--')

x1 = xD
y1 = xD
x2 = xInterp(y1)
y2 = x2
x3 = xInterp(y2)
y3 = x3
x4 = xInterp(y3)
y4 = x4
x5 = xInterp(y4)
y5 = x5
x6 = xInterp(y5)
y6 = x6

plt.hlines(y1,x1,x2)
plt.vlines(x2,y1,y2)
plt.hlines(y2,x2,x3)
plt.vlines(x3,y2,y3)
plt.hlines(y3,x3,x4)
plt.vlines(x4,y3,y4)
plt.hlines(y4,x4,x5)
plt.vlines(x5,y4,y5)
plt.hlines(y5,x5,x6)
plt.vlines(x6,y5,y6)

plt.grid()
plt.title('Total Reflux')
plt.xlabel('x')
plt.ylabel('y')
plt.legend()
;
print(x6)
```

```
0.05235428297778959
```



The minimum bottoms composition with a partial reboiler and partial condenser is $x = 0.052$.