Programming series

Material Balance in Multicomponent Distillation

Just using Python

Swipe

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Overview

Material balance is an essential part in process engineering calculation. This calculation can be done analytically by writing down it on a paper or using computer simulation programs such Matlab, Aspen Hysys, Aspen Plus, and DWSIM. But in this case I will perform the calculation only using python, a multipurpose programming language to solve material balance on multicomponent distillation.

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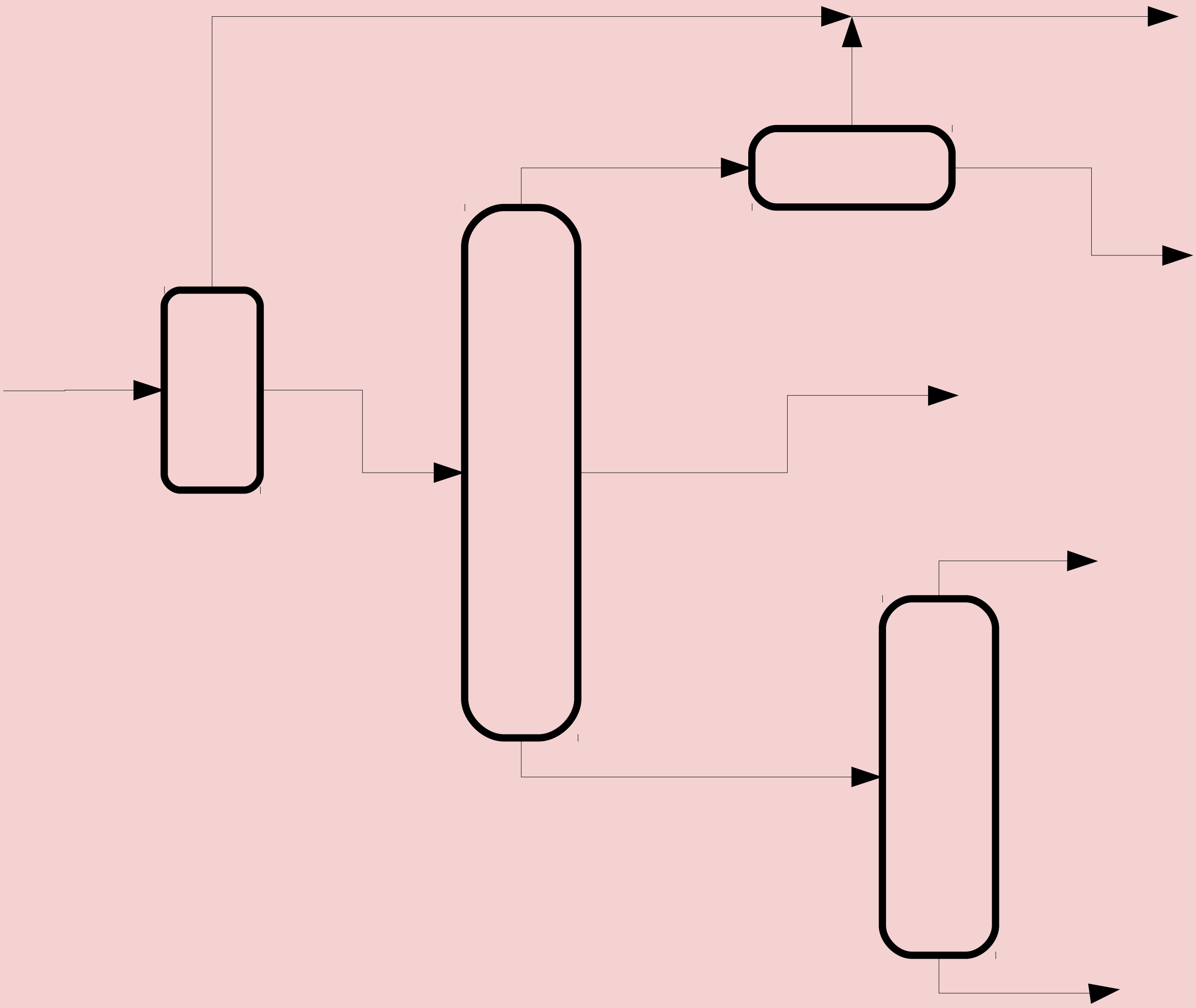
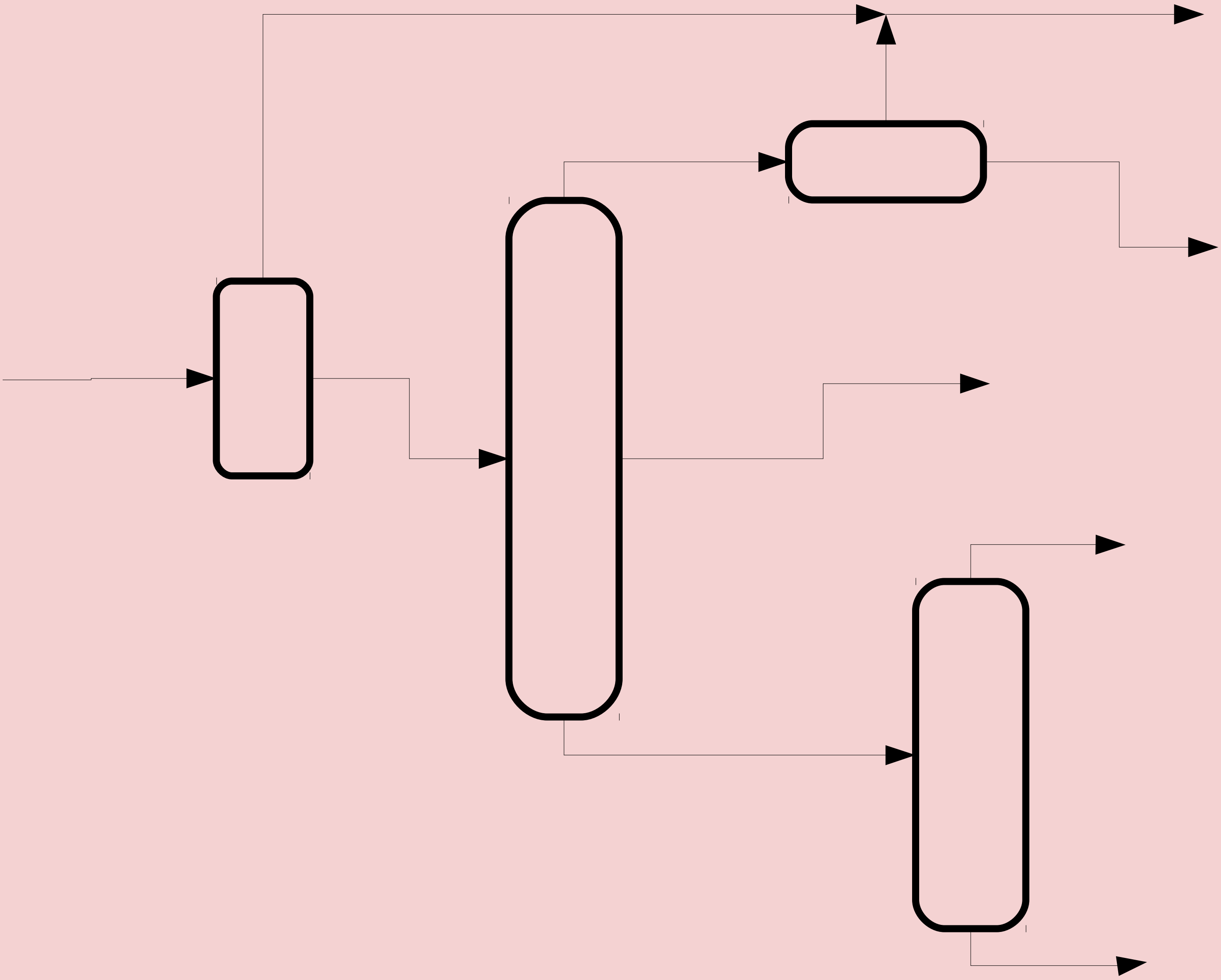
The Problem

Feed that consisting 35 % xylene, 45 % styrene, 15,5 % benzene, 4 % toluene, and the rest are moisture content to be separate at 10.000 kg-mole/h in multicomponent distillation. The feed initially entering dryer (D1) to removing moisture content up to 0,01 % moisture that leaving from the dryer. Then stream are entering distillation column (D1). Styrene considering as a main product that flowing from side stream of the column consisting 98,5 % concentration. The top product consisting as xylene with 96 % concentration. Excess water content are removed that flowing simultaneously with top streamusing partial condenser. The detail can be shown on this picture



The Problem



The Code

Distillation.py

```python
# This program are perform basic mass balance calculations using python
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# June 30 2020

# Import modules
import numpy as np
import scipy.linalg

# Define the constant
F = 10000 # feed flow,kg-mole/h
F_cont = np.array([0.35, 0.45, 0.155, 0.04, 0.005]) #concentration of the
feed, mole percent

# compute feed flow
comp_flow = F*F_cont # flow each component, kg/h

# compute mass balance on the dryer first
F1 = (1-F_cont[4])*F/(1-0.001) #stream that flow leaving dryer
V1 = F - F1 # vapor stream that leaving dryer

# new concentration leaving on dryer
xy = comp_flow[0]/F1 # new xylene concentration leaving dryer
sy = comp_flow[1]/F1 # new styrene concentration leaving dryer
be = comp_flow[2]/F1 # new benzene concentration leaving dryer
to = comp_flow[3]/F1 # new toluene concentration leaving dryer
wa = (comp_flow[4]-V1)/F1 # new water concentration leaving dryer

# construct an array that store new concentration of F1
# this is necessary since we will solve the problem from F1, not as initial
feed
new_cont = np.array([xy, sy, be, to, wa])

# hence the flow each component in stream leaving dryer
F1_comp = F1*new_cont

# now define the concentration each unknown streams in an arrays
xylene = np.array ([0, 0.96, 0.05, 0, 0]) #mole percent
styrene = np.array ([0, 0.04, 0.985, 0, 0]) #mole percent
benzene = np.array ([0, 0, 0.01, 0.995, 0])#mole percent
toluene = np.array ([0, 0, 0, 0.005, 1])#mole percent
water = np.array ([1, 0, 0, 0, 0])#mole percent
x = np.array([xylene, styrene, benzene, toluene, water]) # construct an array

# compute the unknown flow of the streams
flows =scipy.linalg.solve(x,F1_comp) # main solver that solve linear eqn
```

The Code (cont.)

Distillation.py

```
# store and print the results each stream
V2 = flows[0]
LE = flows[1]
Dist = flows[2]
HE = flows[3]
Res = flows[4]
print('Flow excess water vapor from condenser, V2 =', V2, 'kg/h')
print('Flow distillate in top stream, LE =', LE, 'kg/h')
print('Flow distillate in side stream, Dist =', Dist, 'kg/h')
print('Flow top stream in D3, HE =', HE, 'kg/h')
print('Flow bottom stream in D3, Res =', Res, 'kg/h')

# optionally compute the intermediate streams and concentrations
F2 = HE + Res # Bottom stream of D2
V = V2 + LE # Top stream of D2 before entering condenser that consist water vapor
and Light end
Vtot = V1 + V2 # Total water vapored
print('Flow of bottom stream entering D3, F2 =', F2, 'kg/h')
print('Flow of vapor stream in top D3 before entering condenser, V =', V, 'kg/h')
print('Total water removed, Vtot =', Vtot, 'kg/h')
x_benz = (benzene[3]*HE + benzene[4]*Res)/F2 # benzene concentration in F2, mole
percent
x_tol = (toluene[3]*HE + toluene[4]*Res)/F2 # toluene concentration in F2, mole
percent
print('Benzene concentration in F2 (mole percent) =' ,x_benz)
print('Toluene concentration in F2 (mole percent) =' ,x_tol)
```

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