Pressure Swing Distillation for the Separation of Ethyl Acetate and Cyclohexane

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BACKGROUND AND DESCRIPTION:

We demonstrate the Pressure Swing Distillation of ethyl acetate and cyclohexane mixture which is a widely used organic solvent in the pesticide and chemical engineering industries in OpenModelica.

Boiling point of cyclohexane is 80.74°C and ethyl acetate is 77.15°C. But when they mix and mixture is formed then, boiling point of Azeotropic mixture is 72.8°C (when 46% water and 54% pyridine is present). Ethyl acetate and cyclohexane form minimum boiling type azeotrope at atmospheric pressure. That's why we use PSD technique to separate.

DESCRIPTION OF FLOWSHEET:

In the following flowsheet, a double column pressure swing distillation process has been employed, where change in column pressure is used to shift azeotropic compositions. The feed (Feed), with 50% ethyl acetate and 50% cyclohexane, and recycle (Recycle) enters the first High Pressure Distillation Column (HPC1), operating at 1.01325 bar, at stages 11 and 2, respectively (Total stages in HPC1 = 34, Reflux Ratio = 3.66). The first bottom product (Distillate1) obtained is 98.414% cyclohexane while the top stream (S1) enters the adiabatic compressor (C1) with an outlet pressure of 0.5 bar. Then the output of compressor (S2) enters the Low Pressure Distillation Column (LPC2), operating at 5 bar, as feed at stage 28 (Total stages in LPC2 = 35, Reflux Ratio = 2.96). The second bottom product (Distillate2) obtained is 94.34% ethyl acetate while the distillate (S3) is recycled back after the stream (To_Recycle) is increased to its desired pressure of 1.01325 bar by using a valve (V1).

Note: All percentage compositions mentioned above are on mole basis.

FLOWSHEET:

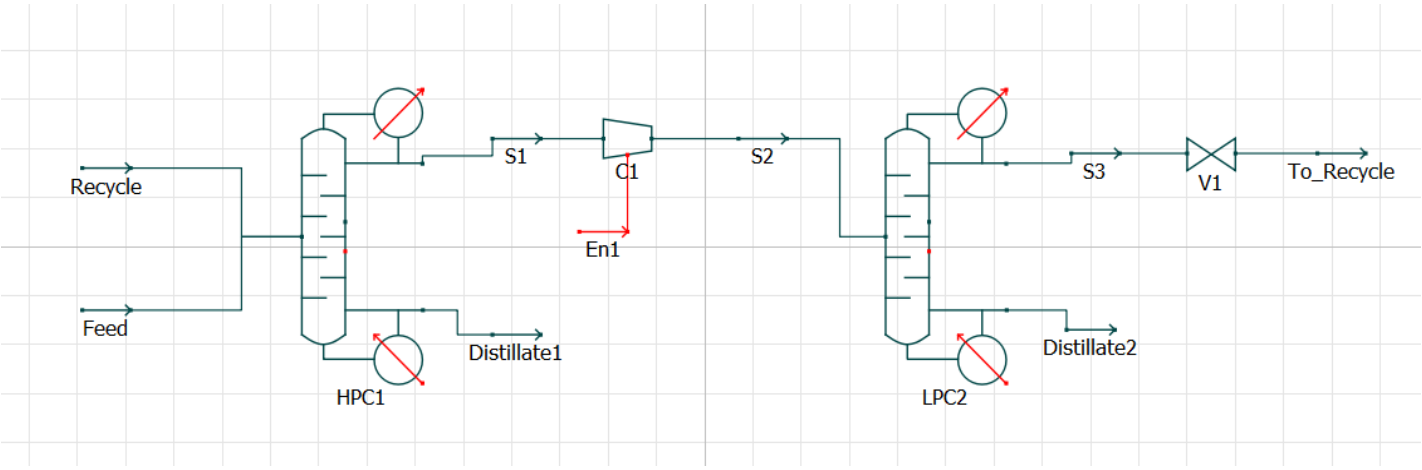

Figure 1: Ethyl acetate and Cyclohexane PSD Separation Flowsheet in OMEdit

RESULTS:

Simulation Results: - DWSIM (Raoult's Law)

Object	FEED	DISTILLATE 1	DISTILLATE 2	UNITS
Temperature	303.15	456.057	183.304	K
Pressure	1013250	1013250	0.5	Pa
Molar Flow	27.7778	14.0133	13.5628	mol/s
Mole Fraction Mixture (Ethyl Acetate)	0.5	0.01	0.999	
Mole Fraction Mixture (Cyclohexane)	0.5	0.99	0.001	

Simulation Results: - OpenModelica (Raoult's Law)

Object	FEED	DISTILLATE 1	DISTILLATE 2	UNITS
Temperature	303.15	455.956	182.771	K
Pressure	1013250	1013250	0.5	Pa
Molar Flow	27.7778	14.0133	13.5628	mol/s
Mole Fraction Mixture (Ethyl Acetate)	0.5	0.01585	0.943362	
Mole Fraction Mixture (Cyclohexane)	0.5	0.98414	0.05663	

It is visible that the values are in good agreement. However, due to convergence issues and to reduce the simulation time, a lot of start values are needed to be provided in the OMEdit Chemical Simulator.

REFERENCE:

Completed DWSIM Flowsheet: Pressure Swing Distillation for the Separation of Ethyl Acetate and Cyclohexane