Pressure Swing Distillation for THF and Ethanol Separation

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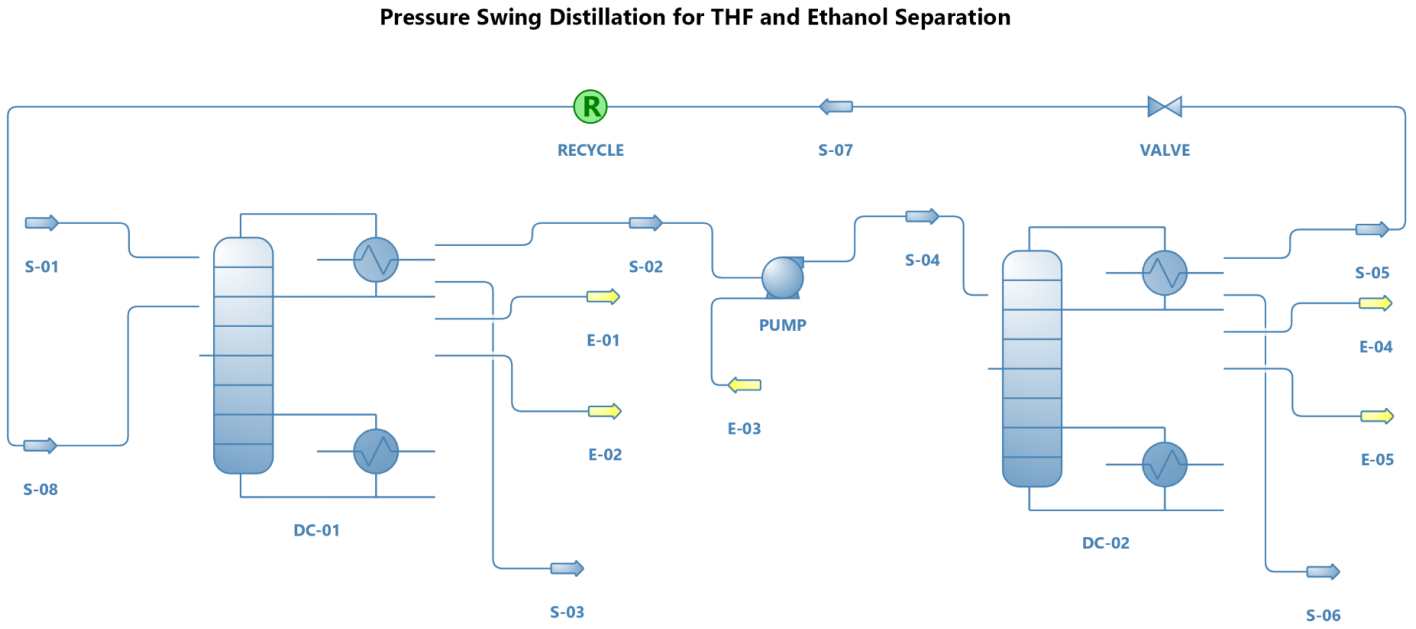
Background:

An effluent containing tetrahydrofuran (THF) and ethanol is formed during the synthesis of a liquid crystal monomer. Since THF and ethanol are both essential solvents in the chemical industry, the mixture of THF and ethanol must be separated for reuse. In some chemical systems, binary mixtures with non-ideal vapour-liquid equilibrium behaviour produce azeotropes. However, since a minimum azeotrope forms in the binary system, it is difficult to separate the mixture through simple distillation effectively.
Pressure Swing Distillation (PSD) is used to isolate mixtures of THF and ethanol containing 50 mol% THF and 50 mol% ethanol. PSD is based on the fact that a change in pressure will change the relative volatility of a liquid mixture, even for liquid mixtures with a low boiling point or those that form an azeotrope. There is no need for an additional component (entrainer). Pressure swing Azeotropic distillation separates azeotropic mixtures in two columns operating at different pressures by taking high-purity liquid streams from one end of the columns and recycling streams from the other end with compositions close to the two azeotropes. The distillate stream from the first column reaches the second column in minimum-boiling systems, while high-purity product streams are collected from the bottom of the columns.

Description of Flowsheet:

The physical property packages UNIFAC and Peng-Robinson (PR) are included.
The flowsheet includes two distillation columns: "DC-01," which acts as a Low-Pressure Column (LPC) at 1 bar, and "DC-02," which acts as a High-Pressure Column (HPC) at 10 bar. The low-pressure column receives a feed mixture of 50 mol% THF and 50 mol% ethanol.DC-01 has 45 trays, with the feed location for feed S-01 on the 30th tray and the recycle stream location for recycling stream S-08 on the 24th tray. The 99.9% pure ethanol product stream S-03 exits the column from the bottom, while the distillate stream S-02 is pumped into the high-pressure column at a pressure of 10 bar. The DC-02 has 44 trays, with the 15th tray serving as a feed location for the feed S-04. The bottom stream S-06 is a 99.9% pure THF. DC-02's distillate stream S-05 is recycled back to the LPC DC-01.
The azeotrope contains 85.82 mol% THF at 1 bar in the THF/ethanol system, whereas it contains 25.67 mol% THF at 10 bar.

Flowsheet:



Results:

The LPC and HPC were independently simulated with a target bottom composition of 99.9 mol% ethanol and 99.9 mol% THF.

	S-01 Feed	S-02 Distillate of LPC	S-03 Ethanol	S-05 Distillate of HPC	S-06 THF	S-08 Recycle
Temperature (℃)	46.8	64.8501	78.6045	147.826	159.946	71.4643
Pressure (bar)	1	1.01325	1.01325	10.132	10.1325	1
Molar Flow (kmol/h)	100	72.7993	49.9999	22.7994	49.9999	22.7994
Molar Fraction (Mixture) / Ethanol	0.5	0.172411	0.999	0.548321	0.001	0.548321
Molar Fraction (Mixture) / Tetrahydrofuran	0.5	0.827589	0.001	0.451679	0.999	0.451679
Energy Flow (kW)	-982.756	-585.946	-490.959	-125.083	-173.972	-125.083

	E-01 LPC C-Duty	E-02 LPC R-Duty	E-04 HPC C-Duty	E-05 HPC R-Duty
Energy Flow (kW)	1786.48	-1807.87	718.721	-1031.22

Reference: [Extractive distillation and Pressure-Swing distillation for THF/ethanol separation]