Extractive Distillation for the Separation of CO2 and Ethane in Oil Recovery Processes

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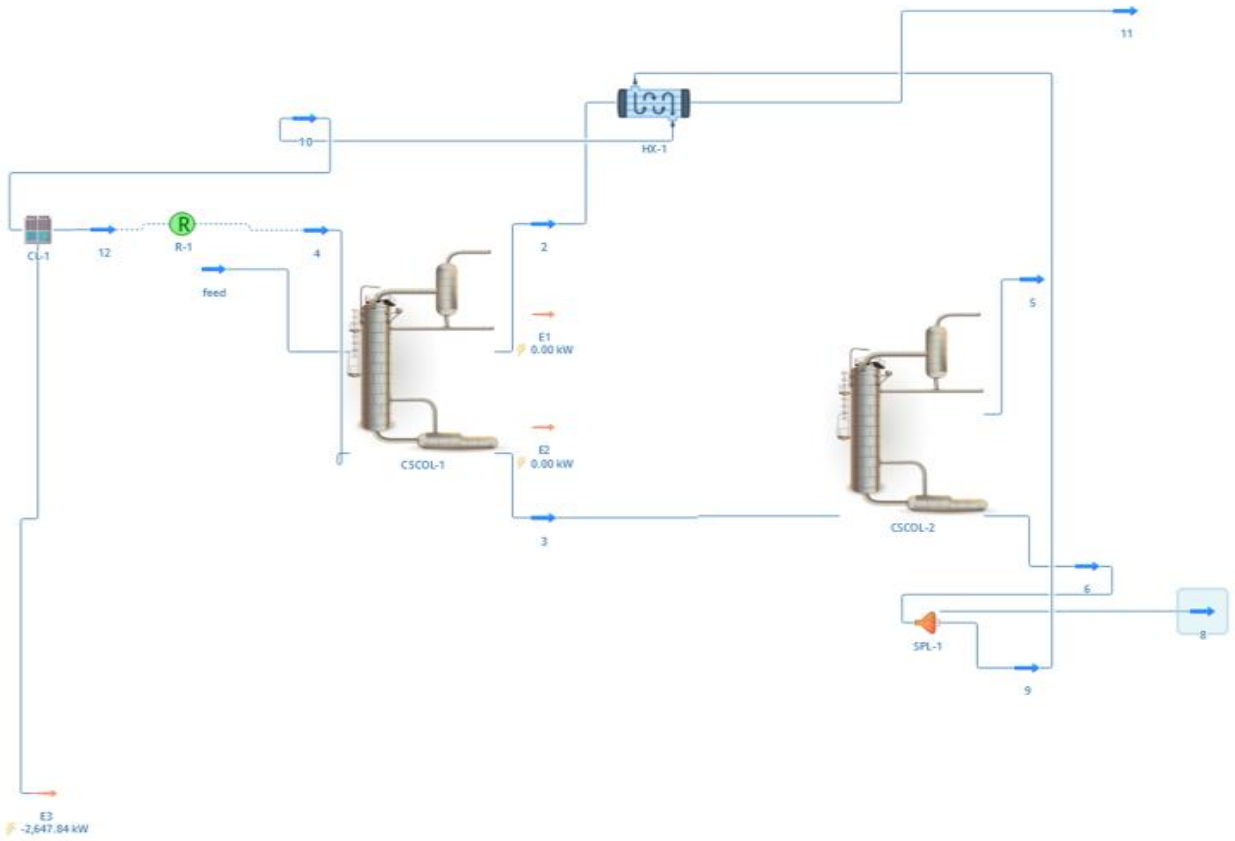
Background & Description: Enhanced Oil Recovery (EOR) injects CO2 into wells to boost crude oil and gas extraction, a proven technique. Resulting gas streams carry CO2 and hydrocarbons from methane to pentanes. A demethanizer separates methane. NGLs are valuable, requiring CO2 removal for recycling.

CO2-ethane separation faces complexity due to azeotrope presence. Prior studies propose n-pentane as an entrainer for extractive distillation. Control in the interconnected two-column process, unaddressed in past research, is this paper's focus. "Good" control here implies stability, minimal deviations, and steady-state precision. flowsheet, modified from Tavan and Hosseini3, presents columns with 51 stages at 24 atm. The gas feed, 14,400 kmol/h, contains 32.25 mol% CO2 and 46.23 mol% C2, with remaining components spanning C3 to nC5.

Thermodynamic package: extractive distillation columns CSCOL-1, CSCOL-2 (Peng-Robinson 78)

Flowsheet:



Results:

Results: The results of the simulation obtained are shown in Table 1. They are in agreement with those obtained by (Luyben, W. L. (2013)) who used Aspen Plus for the design and simulation of the process.

Table 1: Simulation results

PROPERTIES TABLE				
object	3	8	5	feed
Temperature (C)	51.4548	101.812	-0.0619623	46.85
Pressure (bar)	24.0039	24.0039	24.0039	25.3313
Mass Flow (kg/h)	869775	168225	196876	576024
Molar Flow (kmol/h)	18620	3025.75	6517.01	14400
Molar Fraction (Mixture) / Ethane	0.3464	3.69556E-06	0.989937	0.4623
Molar Fraction (Mixture) / Propane	0.2179	0.334146	0.0022535	0.0752
Molar Fraction (Mixture) / Isobutane	0.2326	0.357988	1.41345E-10	0.0753
Molar Fraction (Mixture) / N-butane	0.0998	0.15368	2.66037E-13	0.0323
Molar Fraction (Mixture) / Isopentane	0.0665	0.102312	1.73628E-20	0.0215
Molar Fraction (Mixture) / N-pentane	0.0337	0.0518709	6.52038E-21	0.0109
Molar Fraction (Mixture) / Carbon Dioxide	0.00273	3.71542E-13	0.00780896	0.3225

After obtaining the results through the simulation in DWSIM, it is necessary to validate the results obtained with the scientific reference, by comparing the results to calculate the percentage error. The article used for the validation of the results was carried out by (Luyben, W. L. (2013)). In the validation of the results, the most relevant results were considered. Table 2 shows the validation results.

Table 2: Simulation validation for CO2 mole fraction (Error)

Variable	Description	Units	DWSIM	(Luyben, W. L. (2013))	ERROR
3	Hot fluid outlet of HX-1	-	0.00273	0.0005	0.81
8	Outlet stream of SPL-1	-	3.71542E-13	0.0006	-
5	Top product of the column-2	-	0.00780896	0.0014	0.82
feed	Feed of the column-1	-	0.3225	0.3225	-

References:

Luyben, W. L. (2013). Control of an extractive distillation system for the separation of CO2 and ethane in enhanced oil recovery processes. *Industrial & Engineering Chemistry Research*, *52*(31), 10780-10787.