CO2 Capture and Compression using MEA

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Background

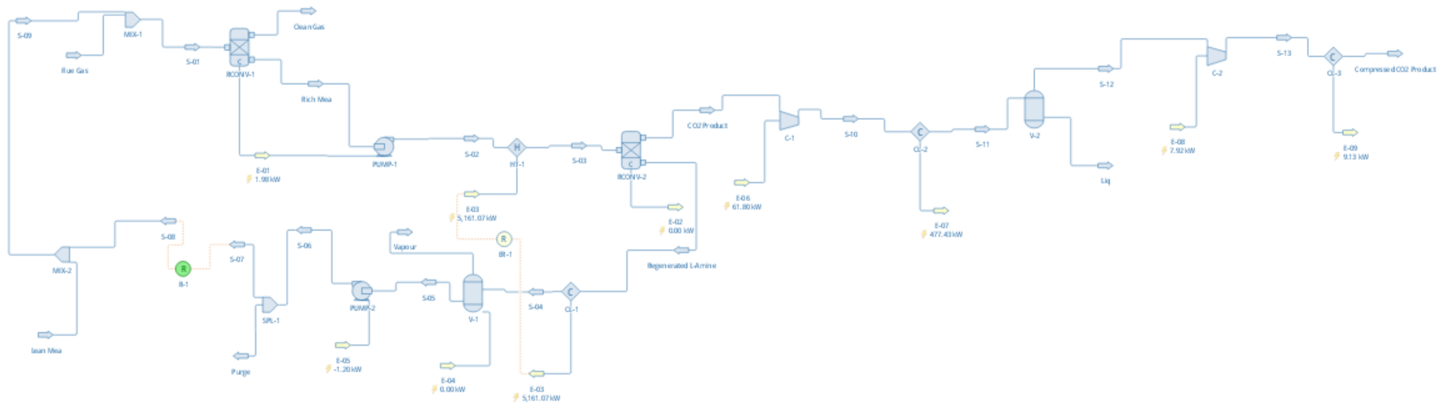
The increasing concentration of carbon dioxide (CO_2) emissions from industrial sources has become a major environmental concern due to its contribution to global warming and climate change. Among the available carbon capture technologies, post-combustion CO_2 capture using aqueous monoethanolamine (MEA) is one of the most widely adopted methods because of its high absorption efficiency, operational reliability, and industrial maturity. Process simulation plays an important role in analyzing the performance of CO_2 capture systems while minimizing the need for costly experimental investigations. This project presents the simulation of an integrated MEA-based CO_2 capture and solvent regeneration process using DWSIM.

Description

A flue gas stream containing carbon dioxide, nitrogen, oxygen, and water vapor is mixed with regenerated lean MEA solution and fed to the absorber, where CO_2 is chemically absorbed by the solvent. The absorption and regeneration reactions are represented using conversion reactors with a pseudo-component to model MEA carbamate formation. The CO_2-rich solvent (rich MEA) is then pressurized using a pump and heated before entering the regenerator, where the absorbed CO_2 is released and recovered as a product stream.

The regenerated lean MEA leaving the regenerator is cooled and passed through a gas-liquid separator to remove any remaining vapor before being pressurized and recycled back to the absorber. A purge stream is incorporated into the recycle loop to prevent the accumulation of impurities and maintain stable process operation. Material and energy balances are satisfied throughout the flowsheet, and the recycle stream is solved using DWSIM's recycle block to achieve convergence. The recovered CO_2 stream is produced in gaseous form and is suitable for subsequent compression, transportation, or storage.

Flowsheet



Result

Streams	Flue Gas	Clean Gas	Compressed CO2 Product	Regenerated L-amine
Temperature	315.19 K	299.375 K	298.15 K	382.48 K
Pressure	101.235 KPa	96.325 KPa	813.675 Kpa	183.325 KPa
Mole flow/CO2	5.94 mol/s	0.559 mol/s	4.733 mol/s	0.0429 mol/s
Mole flow/MEA	0 mol/s	0.0022 mol/s	0 mol/s	110.616 mol/s
Mole flow/Water	0.516 mol/s	0.766 mol/s	0.027 mol/s	468.76 mol/s
Molar flow/Overall	32.27 mol/s	27.1322 mol/s	4.76 mol/s	561.79 mol/s

Further Work

The present flowsheet employs Conversion Reactors to represent the absorption and regeneration processes, providing a simplified approximation of the behavior of the absorber and stripper units. In future work, these reactors can be replaced with rigorous Absorber and Stripper column models when DWSIM provides support for the Electrolyte NRTL (E-NRTL) property package or when an appropriate Amines property package becomes available. Furthermore, the current heating and cooling units can be replaced with a lean-rich heat exchanger to recover thermal energy from the regenerated lean MEA stream for preheating the rich MEA stream.

Reference - Harun, N., Nittaya, T., Douglas, P. L., Croiset, E., & Ricardez-Sandoval, L. A. (2012). Dynamic simulation of MEA absorption process for CO_2 capture from power plants. *International Journal of Greenhouse Gas Control*, 10, 295–309.