Closed Cycle Liquefaction for CO_2

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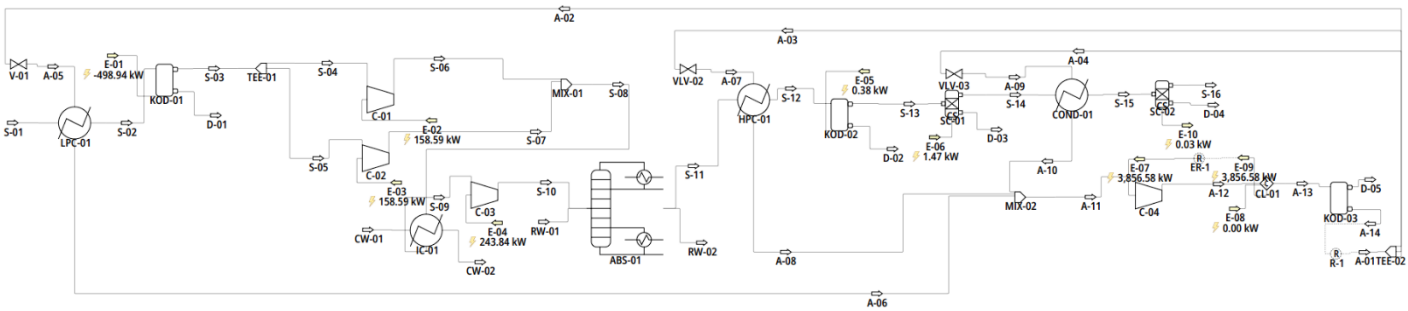
Thermodynamic Package: Peng-Robinson
It is known to be suitable for modeling nonpolar and slightly polar compounds, but may not be as accurate for highly polar compounds or systems with significant hydrogen bonding.

Background:

Liquefaction of CO_2 is an intermediate step for the storage and logistics. Two processes are suggested to achice liquid CO2: The traditional method is based on external refrigeration and Ammonia is used as a refrigerant. In the internal refrigeration process, liquefaction is achieved by compression, cooling and expansion of the CO_2.
In a liquefaction process with an external refrigerant, CO_2 is compressed directly to the transport or intermediate storage pressure. Then it is liquefied using an external refrigeration cycle. Ammonia is preferred due to its less power consumption. The cooling is called external because the refrigerant is not in contact with the main (CO_2) gas.

Description:
The feed stream (S-01) enters to a low-pressure cooler (LPC-01) where it is cooled and depressurized using Ammonia (A-05). Then, it enters the knockout-drum (KOD-01), where the light-liquid water part is discarded (D-01). The resultant vapor stream is then sptil using a splitter (TEE-01) and the streams (S-04 and S-05) enter compressors (C-01 and C-02) respectively. Presence of two compressors acts a fail-safe mechanism in case one of the two fails. The resultant streams are mixed in mixer (MIX-01) and stream (S-08) enters the intercooler (IC-01) where it is cooled using cooling water (CW-01) stream and sent to absorber column (ABS-01). Here, raw water (RW-01) is used as an absorbent and CO_2 is absorbed. The resultant stream (S-11) is sent to a high-pressure cooler (HPC-01) where Ammonia is used as a cooling fluid. Then, the resulting stream (S-12) is sent to knockout drum (KOD-02). The resultant stream (S-13) is sent to a stripping column (SC-01) where Methane and Nitrogen impurities are stripped off. Finally, stream (S-14) enters the condenser (COND-01) where it condensed to liquid phase. Stream (S-15) is again passed through a stripping column (SC-02) to remove the remaining Methane, Nitrogen and Water impurities and we obtain the product stream (S-16).
This process is a closed-cycle process. Thus, the outlet Ammonia streams (A-06, A-08, A-10) from low-pressure cooler (LPC-01), high pressure cooler (HPC-01) and condenser (COND-01) respectively; is compressed in (C-04), cooled in (CL-01) and recycled back (via R-1) to the process.
Note: The Absorber Column (ABS-01) is simulated using ChemSep.

Flowsheet:



Results:

Stream	S-01	S-04/S-05	S-08	S-09	S-11	S-12	S-14	S-15	S-16	A-01
Temperature (in °C)	60	7.006	165.553	30.61	24.184	7.128	7	-28	-28	30.764
Pressure (in bar)	1.2	1.1	5.8	5.07	17.93	17.93	17.7	17.6	17.6	11.9
Vapor Phase Fraction	0.983	0.999	1	1	1	0.998	1	0	0	0
Phase	V+L	V+L	V	V	V	V+L	V	L	L	L
Mole Fraction of CO2	0.833	0.992	0.992	0.992	0.998	0.998	0.998	0.998	1	0
Mass Flow (in kg/hr)	8727.24	4045.1	8090.21	8090.21	8041.2	8041.2	8034.7	8034.7	8033.73	10800

Reference: Simulation and Cost Comparison of CO2 Liquefaction - ScienceDirect