Separation of Natural Gas

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Background

One of the important process in the chemical engineering is the natural gas processing. Moreover, improved production methods due to increased supply and decreased cost of natural gas has gone to make the process much more significant. Though the composition of natural gas varies from source to source but it mostly constitute of methane (85%) with small amount of ethane, propane, n-butane, isobutane and heavier hydrocarbons. C2 and heavier hydrocarbons are more valuable than methane and hence it is very important to recover them. C2 and heavier hydrocarbons are called as Natural Gas Liquid. Recovery is accomplished in a series of five distillation columns.

Description of the Flowsheet

Recovery of hydrocarbons from the natural gas feed is achieved by using series of distillation columns. First, methane is separated out in a high pressure cryogenic distillation column using expansion. The column is named as de-methanizer and designed in a way to keep low concentration of methane in its bottom product. The column is operated at 25 atm and 180 K. De-ethanizer is the second column used in the process to recover ethane. The column operates at 21 atm and 264 K. Refrigeration is used in the condenser and column is designed such that distillate only has specified concentration of propane impurity. De-propanizer is the third column used in the process to recover propane as distillate, operating at 17 atm and 322 K. Cooling water is used in the condenser and designed such that bottom only has specified concentration of propane impurity. De-butanizer is the fourth column to carry n-butane and isobutane as overhead product for further separation in another column. Due to lowest relative volatility of iC4/nC4, its separation is most difficult. Hence its separation is performed after all the lighter and heavier components are removed. Also it makes the process more economical. The column is operated with reflux drum temperature of 322 K and 7.1 atm pressure.

The last column is de-isobuanizer. It separates isobutane as distillate and n-butane as bottom. The column is designed in a way such that n-butane has specific concentration as impurity in distillate and isobutane as impurity in bottoms. Column is operated at 322 K temperature and 6.6 atm pressure.

Peng-Robinson thermodynamics model is employed in this flowsheet.

Results

Below displayed are the stream-wise results from the flowsheet:

	NG-Feed	Methane	Ethane	n-Butane	i-Butane	Propane	Stabilized Condensate
Temperature (K)	310	373.356	269.104	339.6	322.391	322.893	391.494
Pressure (atm)	59	60	21	7.4	6.6	17	7.4
Mass Flow (kg/h)	101880	77310.2	8564.92	2517.72	2127.09	6429.33	4930.63
Molar Flow (kmol/h)	5269	4699.1	282.185	43.273	36.6306	145.698	62.115
Volumetric Flow (m3/h)	1933.53	2283.18	20.5277	4.84072	4.10123	14.2866	9.1648
Mixture Molar Weight (kg/kmol)	19.3357	16.4521	30.3522	58.1821	58.0686	44.1277	79.379
Molar Fraction (Mixture) / Methane	0.864	0.968784	1.87E-05	0	7.52E-20	3.58E-16	1.49E-17
Molar Fraction (Mixture) / Ethane	0.0647	0.0134972	0.979845	2.64E-21	1.58E-13	0.00671413	6.46E-20
Molar Fraction (Mixture) / Propane	0.0287	0.000420943	0.0201363	1.06E-17	0.00387705	0.984386	6.78E-12
Molar Fraction (Mixture) / Isobutane	0.0072	1.82E-05	1.18E-07	0.02	0.97544	0.00857944	7.46E-05
Molar Fraction (Mixture) / N-butane	0.0082	1.11E-05	1.39E-08	0.975785	0.0206825	0.000320926	0.002
Molar Fraction (Mixture) / Isopentane	0.0041	8.15E-07	1.43E-13	0.003693	1.93E-17	3.81E-10	0.345154
Molar Fraction (Mixture) / N-pentane	0.0031	3.50E-07	2.17E-14	0.000522102	5.46E-21	5.22E-11	0.262572
Molar Fraction (Mixture) / N-hexane	0.0031	1.93E-08	2.38E-24	2.88E-10	1.19E-24	5.53E-20	0.26296
Molar Fraction (Mixture) / N-heptane	0.0015	6.12E-10	2.33E-22	9.79E-16	1.96E-24	2.77E-22	0.12724
Molar Fraction (Mixture) / Nitrogen	0.0154	0.0172677	4.29E-12	0	0	1.29E-22	3.35E-21

References

Luyben, William L. “Control of a Train of Distillation Columns for the Separation of Natural Gas Liquid.” *Industrial & Engineering Chemistry Research*, vol. 52, no. 31, July 2013, pp. 10741–10753., doi:10.1021/ie400869v

Flowsheet Source: http://www.chemsep.com/downloads/data/NG_Train_IECR52p10741.png