Air Liquefaction using Linde Single-Column System

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A. Background:

Air is a mixture of various types of gases and each constituent gas has a wide range of applications. Atmospheric air contains 78.08% nitrogen, 20.95% oxygen, 0.93% argon 0.04% other gases by volume (on dry basis). Separation of air into its constituent components are of significant relevance to the fertilizer and medical technology industry. Specifically, the pandemic period created a sudden surge in the oxygen requirement across hospitals. There are various technologies for separation process, the most common being cryogenic distillation. In addition to the cryogenic method, there are other methods such as Membrane, Pressure Swing Adsorption (PSA) and Vacuum Pressure Swing Adsorption (VPSA), which are typically used to separate a single component. The Linde Single-Column System is a cryogenic separation system which can separate both Oxygen and Nitrogen by liquefying air.

B. Process Description:

The Process Flow Diagram for Linde Single-Column System for Air Liquefaction is shown below, as adapted from Bose (2012). The flowsheet based on Bose (2012) is developed in DWSIM (v7.3.1).

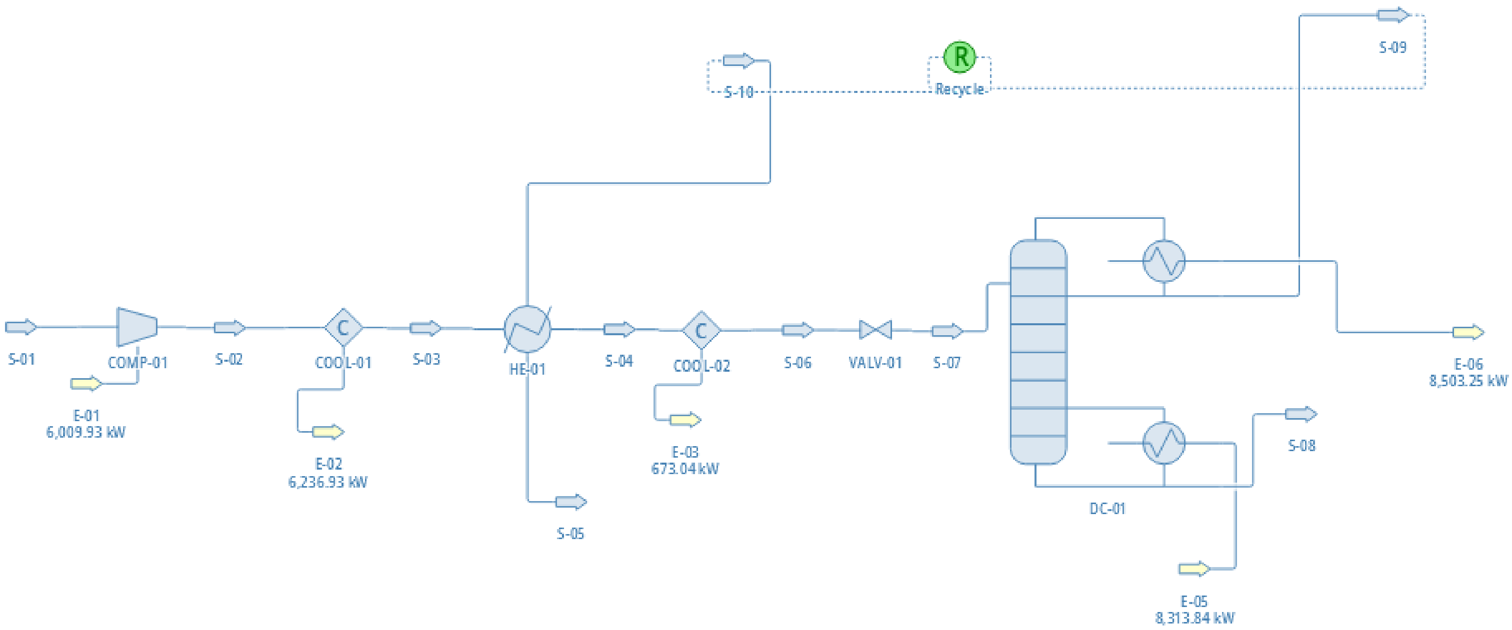

Figure 1. Process Flow Diagram of Linde Single-Column system for air liquefaction.

Feed air is assumed to comprise of only Nitrogen and Oxygen, other constituent gases like Argon, CO_2, water vapour are neglected. The feed air enters a compressor (Compressor). The compressed air is cooled (Cooler 01) and passed through a heat exchanger (Hex 01) in which the incoming air is cooled. A two-channel type heat exchanger is used to separate the oxygen in liquid phase. The liquid oxygen is then withdrawn from the lower section of the column.

The cold air is expanded through a pressure valve (Valve), wherein some liquid is formed. This liquid is then passed to the top of the column (Distillation Column) and flows down across the plates. The liquid flowing down is enriched in oxygen by exchange with the upward-flowing vapor. When the liquid reaches the bottom of the column, a portion is evaporated by the incoming air. This vapor flows up the column, bubbling through the liquid layers and carrying nitrogen on its way. The gas at the top of the column is removed (Distill) and passed through the heat exchanger (Recycled Distill) to help cool the incoming air.

C. Operating Conditions for Simulation

Air is assumed to comprise of 79% Nitrogen and 21% Oxygen, all other constituent gases are neglected. The thermodynamic model used was the Peng Robinson Model. The operating conditions are as follows:

- Ambient Temperature = 298 K
- Ambient Pressure = 1 atm
- Maximum Pressure for Compression = 200 atm
- Molar Flow Rate = 200 mol/s
- Number of stages = 7 (100% efficient)

D. Results

Nitrogen of 90% purity and Oxygen of 99% purity were obtained after separation

The important result streams are tabulated in Table 1 below.

Table 1. Important result streams from simulation of Air Liquefaction using Linde Single-Column System

Parameter	**S-01**	**S-02**	**S-07**	**S-09**	**S-08**	**Units**
Temperature	24.85	960.91	-194.15	-195.23	-183.21	**C**
Pressure	1.01	202.65	1.01	1.01	1.01	**bar**
Mass Flow	20772.20	20772.20	20772.20	17893.70	2878.50	**kg/h**
Molar Flow	720.00	720.00	720.00	630.00	90.00	**kmol/h**
Molar Fraction (Vapor)	1.00	1.00	0.17	0.00	0.00	**-**
Molar Fraction (Liquid 1)	0.00	0.00	0.83	1.00	1.00	**-**

E. Further Works

The process was simulated assuming that air comprised of Nitrogen and oxygen alone. Therefore, incorporating other constituent gases like Argon and CO_2 and the separation of the same prior to liquefaction can be implemented as future scope.

F. Reference

Bose A. (2012). Simulation of Air Liquefaction Using Aspen Plus. B. Tech. Project Report, National Institute of Technology (NIT), Rourkela.