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Comparative study on simulations of Linde double column and Linde Frankl for the production of liquid nitrogen and liquid oxygen using DWSIM

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Highlights:

- Comparison of Linde double column and Linde-Frankl processes were performed using DWSIM
- The Peng-Robinson equation of state was chosen for accurate cryogenic behavior prediction.
- The optimized Linde double column process achieved 99.99% liquid nitrogen (LN₂) and 99.9% liquid oxygen (LOX) purity.
- The simulation was designed to have a safety factor of 2.

Abstract:

Two of the most important cryogenic fluids are liquid nitrogen (LN₂) and liquid oxygen (LOX), which have many applications in medicine, aircraft, food preservation, and metal production. Industries used various production techniques to fulfill the massive demand for these liquids. The two most well-known of these are the Linde-Frankl (LF) and Linde double-column (LD) processes. The LD and LF procedures were replicated in an open-source and user-friendly program called DWSIM to generate LN₂ and LOX, respectively, and then compared. Since the Peng-Robinson equation of state well predicts the thermodynamic

behaviour of actual gases and can successfully manage the Vapour-Liquid Equilibrium (VLE) computations, and it was used as a thermodynamic model in both simulations. Compared to the LF process, the LD process demonstrated higher product purity and greater efficiency thorough simulation study. The distillation columns used in the LD process were the subject of an optimization study. The results showed that the primary column had 20 stages and a reflux ratio of 1.5, while the secondary column had 45 stages and a reflux ratio of 15. This allowed for the production of extremely pure products (Liquid Nitrogen up to 99.99% and Liquid Oxygen up to 99.9%) while minimizing wastage (purge stream flow rate = 129.956 Kmol/hr).

Keywords: Liquid Nitrogen, Liquid Oxygen, DWSIM, Linde double-column process, Linde-Frankl process;

I. Introduction:

Chemical processes often make use of airborne components like nitrogen and oxygen. The medical field, chemical industry, aerospace, chemical, semiconductor, refining, food processing, and many more industries rely on significant quantities of high-purity air products..Gases in the air include mostly nitrogen, oxygen, and argon, but also trace amounts of other elements and compounds such as carbon dioxide, water vapor, and neon.

The first real use of cryogenic technology was air separation. These days, air separation is among the most cutting-edge and competitive techniques. Nitrogen and oxygen are produced by air separation plants with huge capacities. At temperatures below -196°C , air turns into a liquid, which allows us to separate it into its component elements. Nowadays, the most common method for producing industrial quantities of pure oxygen and nitrogen is to distil the air[1]. Integrated Gasification Combined Cycle (IGCC) and other industrial processes rely on clean oxygen and nitrogen. A gasifier receives oxygen and a gas turbine receives nitrogen. Air separation is now a crucial step in many production procedures.[2][3].

Originally meaning "the process of producing very cold temperatures," the term "cryogenic" has come to mean "low temperatures" in common use. Cryogenic operating temperatures are defined as those below 123K by the National Bureau of Standards in Boulder, Colorado. Techniques, procedures, and equipment that operate at low temperatures are the focus of cryogenic engineering. Cryogenic systems typically include a collection of interconnected parts that work together at very low temperatures. The following are some examples: helium freezers, air liquefaction plants, etc. The gaseous and liquid Oxygen, Nitrogen, and argon product flows are formed by the compression, purification, and separation of the air input into the various units that make up the cryogenic process [4].

Two processes formed the basis for the manufacturing of LN₂ and LOX—liquid nitrogen and oxygen, respectively. The first is the Linde Double-Column (LD) system, also known as Double-Column rectification, which uses fractional distillation at two pressures to separate air into pure nitrogen and oxygen. The second is the Linde-Frankl (LF) process, which uses high pressure and combines isentropic expansion with Joule-Thomson expansion for improved efficiency.

This study utilizes the well-known DWSIM program to simulate the Linde double column and Linde-Frankl processes for producing liquid nitrogen and liquid oxygen from air that contains nitrogen, oxygen, and argon[5]. The best method for producing LN₂ and LOX on an industrial scale was determined by simulating their capacity for separation, operational practicality, and product purity. In order to choose the best cryogenic air separation technique, this research gives crucial information. Additionally, it offers an optimization study to determine the best way to enhance the product's purity even further.

II. METHODOLOGY

The Linde-Frankl and Linde double column processes were modelled to liquify nitrogen and oxygen with the help of DWSIM[6]. Because it is useful for approximating the behavior of actual gases even at cryogenic temperatures and high working pressures, the Peng-Robinson equation of state is used as the thermodynamic model in the simulations. A basis of 4089.35 Kmol/hr (1,00,000 m³/hr) of air containing 78.1% nitrogen, 20.9% oxygen, and 1% argon is taken as feed for both the simulations[7]. The approach that yielded the best results was selected after comparing the two simulations using several criteria. Optimal performance of the distillation columns was investigated. The optimization was carried out by selecting the optimal operational variable, such as the number of stages or reflux ratio, in order to maximize purity and product flow rate while keeping costs manageable.

Linde Double Column Process:

The simulation of the Linde double-column method was shown in **Fig 1**. The first step in this procedure is to dry out the air and eliminate any solid particles or moisture or other contaminants. Everything here is predicated on the air being dry and filtered. First, the air (air inlet) is adiabatically compressed to 100 bar pressure from its initial state of 25 °C and 1.01325 bar (S-1). The act of compression raises the air temperature to 890.271 °C. The air is cooled from 890.271 °C to 25 °C using a cooler (S-2). The liquid nitrogen from the primary distillation column is used to further cool the air from its initial temperature of 25 °C to -100 °C via a heat exchanger (S-3). Now, a cooler is used to further chill the air, which is already at -100 °C to -180 °C (S-4). The next step is to push the stream out of the valve's nozzle using an expansion engine valve. The air experiences the Joule-Thompson effect as a result of the abrupt expansion to 1.01325 bar, turning the stream into 84.1% liquid sufficient for separation (S-5). Afterwards,

the feed is distilled in a primary distillation column. Because nitrogen is highly volatile, it is retrieved from the upper part of the column (liquid N₂ distillate) while the oxygen-rich stream is allowed to flow out through bottom of the column. This liquid nitrogen is used as cold stream in the heat exchanger (S-6). Using the stream's latent heat, the heat exchanger cools the air passing through it. The nitrogen gas (S-7) is cooled down to liquid state (liquid N₂ outlet) once it exits the heat exchanger. In this way, liquid nitrogen is produced. The Oxygen-rich stream from the bottom of the primary distillation column is sent to a secondary distillation column, where Liquid Oxygen is obtained as the bottom product (liquid O₂ outlet). A small waste stream containing Oxygen and argon will leave as the top product of the column (purge stream). This stream is purged into the atmosphere as it only contains oxygen and argon (a small amount of nitrogen)[8].

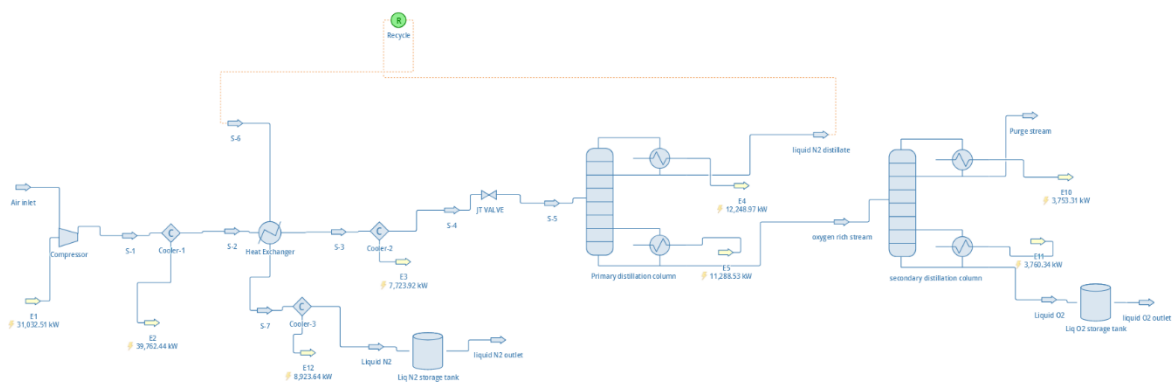


Fig 1Simulation of the Linde double column process

Table 1 Transport properties of streams in the Linde double column process

Stream	Temperature	Pressure	Molar Flowrate	Volumetric Flowrate	Phases	Composition

	°C	bar	Kmol/hr	m ³ /hr		N ₂	O ₂	Ar
Air inlet	25	1.01325	4089.35	100000	V	0.781	0.209	0.01
S-1	890.27	100	4089.35	4063.31	V	0.781	0.209	0.01
S-2	25	100	4089.35	1004.12	V	0.781	0.209	0.01
S-3	-100	100	4089.35	396.673	V	0.781	0.209	0.01
S-4	-180	100	4089.35	144.946	V	0.781	0.209	0.01
S-5	-194.105	1.01325	4089.35	4167.47	V+L	0.781	0.209	0.01
Liquid N ₂ distillate	-195.904	1.01325	3185.53	110.452	L	0.9998 85	1.6*10 ⁻⁵	9.9*10 ⁻⁵
Oxygen-rich stream	-181.825	1.21325	903.811	25.6156	L	0.01	0.945	0.045
Purge stream	-184.792	1.10325	153.131	4.4355	L	0.06	0.68	0.26
Liquid O ₂ outlet	-180.613	1.30325	750.68	102.291	L	0	0.999	0.001
S-6	-195.904	1.01325	3185.53	110.452	L	0.9998 85	1.6*10 ⁻⁵	9.9*10 ⁻⁵
S-7	-110.557	1.01325	3185.53	42280.3	V	0.9998 85	1.6*10 ⁻⁵	9.9*10 ⁻⁵

Liquid	-196	1.01325	3185.53	110.393	L	0.9998	1.6×10^{-5}	9.9×10^{-5}
N ₂						85		
outlet								

115

116 **Note:** here, S represents stream i.e S-1 means stream-1.

117 **Table 1** shows the transport properties like temperature, pressure, molar flow,
 118 volumetric flow, and compositions of the streams of the Linde double column process. By
 119 observing the simulation flowsheet, the change of properties of the streams is based on the unit
 120 operation being carried out on that stream. The change in the properties follows the Peng-
 121 Robinson EOS model.

122 **Linde-Frankl Process:**

123 The simulation of the Linde double-column method was shown in **Fig 2**. Similar steps
 124 are followed in this process as in the previous one; however, this process is run constantly at
 125 high pressures. The first step in this procedure is to dry out the air and eliminate any solid
 126 particles or moisture, or other contaminants. Everything here is predicated on the air being dry
 127 and filtered. The first step is to send the purified air (air inlet), which is at 25 °C and 1.01325
 128 bar, to a compressor, where it is adiabatically compressed to a pressure of 6.8 bar. The act of
 129 compression raises the air temperature to 290 °C (S-1). A cooler is used to reduce the air
 130 temperature from 290 °C to 38 °C (S-2). This stream is split into 2 streams, i.e, a larger stream
 131 of 65% mass flow rate (S-3) and a smaller stream of 35% mass flow rate (S-4).

132

133 Liquid nitrogen from the high-pressure distillation column is used as the cold stream
 134 (S-12) to cool the larger air stream from 38 °C to -107.7 °C (S-4) in a heat exchanger (HX-1).
 135 By using a cooler, the temperature is further lowered to -174 °C (S-5).

136

A compressor is used to adiabatically compress the smaller stream (S-4 at 38 °C and 6.8 bar) from 6.8 bar to 202.65 bar. This causes the stream's temperature to rise to 640.408 °C (S-7). The stream is cooled from 640.408 °C to -100 °C (S-8) using a cooler. With the help of a high-pressure heat exchanger (HX-2), the stream's temperature is further decreased to -160 °C (S-9). The cold stream (S-14) of the heat exchanger is made up of the liquid oxygen that comes out of the low-pressure distillation column. The next step is to push the stream out of the valve's nozzle using an expansion engine valve. The stream undergoes the Joule-Thompson effect and becomes 82.81% liquid as a result of this abrupt expansion to 7.09 bar (S-10).

Both the larger and smaller streams are mixed which resulting in a 94.47% liquid, which is enough for separation (S-11). Next, the stream is sent to a distillation column that operates at high pressure. Because nitrogen is so easily vaporized, it is retrieved from the upper part of the column (liquid N₂ distillate) while the oxygen-rich stream is retrieved from the bottom. Reusing the liquid nitrogen, it feeds the first heat exchanger as a cold stream (S-12). Cooling the entering air is achieved by using the stream's latent heat. After exiting the heat exchanger, the nitrogen is cooled to a liquid state using a cooler (liquid N₂ outlet). Liquid oxygen is produced as the bottom product of a low-pressure distillation column (liquid O₂) by sending the oxygen-rich stream from the bottom of the high-pressure column to it. This liquid oxygen stream is used as the cold stream (S-14) for cooling the incoming smaller air stream in the high-pressure heat exchanger (HX-2). A small waste stream (purge stream) containing nitrogen, oxygen, and argon will leave as the top product of the low-pressure column. This stream is purged into the atmosphere as it only contains nitrogen, oxygen, and argon[9].

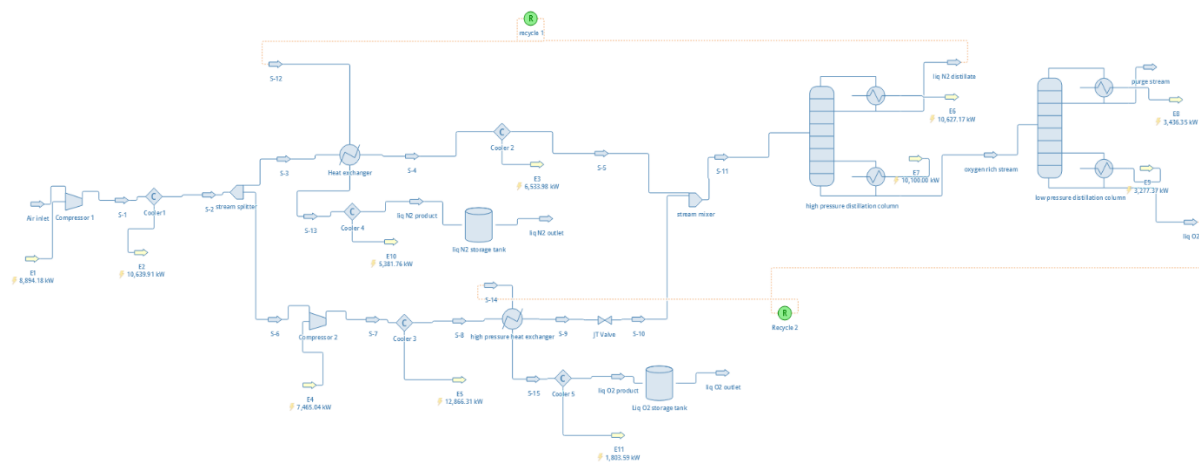


Fig 2:Simulation of the Linde-Frankl process

Table 2:Transport properties of streams in the Linde-Frankl column process

Stream	Temperature	Pressure	Molar Flowrate	Volumetric Flowrate	Phase	Composition		
	°C	bar	Kmol/hr	m ³ /hr		N ₂	O ₂	Ar
Air inlet	25	1.01325	4089.35	100000	V	0.781	0.209	0.01
S-1	289.957	6.8	4089.35	28225.5	V	0.781	0.209	0.01
S-2	38	6.8	4089.35	15528.2	V	0.781	0.209	0.01
S-3	38	6.8	2658.07	10093.4	V	0.781	0.209	0.01
S-4	-107.699	6.7	2658.07	5268.42	V	0.781	0.209	0.01
S-5	-174	6.7	2658.07	101.693	L	0.781	0.209	0.01
S-6	38	6.8	1431.27	5434.88	V	0.781	0.209	0.01
S-7	640.408	202.65	1431.27	572.616	V	0.781	0.209	0.01
S-8	-100	202.65	1431.27	81.3273	V	0.781	0.209	0.01
S-9	-160	202.55	1431.27	57.9161	V	0.781	0.209	0.01
S-10	-171.969	7.09275	1431.27	291.034	V+L	0.781	0.209	0.01
S-11	-172.955	6.7	4089.35	386.861	V+L	0.781	0.209	0.01
LiquidN ₂ distillate	-179.196	5	3152.54	121.717	L	0.99976	0.00004	0.0002

Oxygen-rich stream	-165.174	5.2	936.804	29.3643	L	0.045	0.912	0.043
Purge stream	-183.025	2	133.539	4.2926	L	0.314	0.445	0.241
Liquid O ₂	-174.983	2.2	803.265	23.327	L	0	0.99	0.01
S-12	-179.196	5	3152.54	121.717	L	0.99976	0.00004	0.0002
S-13	-179	4.9	3152.54	4396	V	0.99976	0.00004	0.0002
Liquid N ₂ outlet	-180	4.9	3152.54	120.973	L	0.99976	0.00004	0.0002
S-14	-174.983	2.2	803.265	23.327	L	0	0.99	0.01
S-15	-175.502	2.1	803.265	2803.12	V+L	0	0.99	0.01
Liquid O ₂ outlet	-180	2.1	803.265	22.7914	L	0	0.99	0.01

164

165 **Note:** here, S represents stream i.e S-1 represents steam-1.

166 **Table 2** shows the transport properties like temperature, pressure, molar flow,
 167 volumetric flow, and compositions of the streams of the Linde-Frankl process. By observing
 168 the simulation flowsheet, the change of properties of the streams is based on the unit operation
 169 being carried out on that stream. The change in the properties follows the Peng-Robinson EOS
 170 model.

171 III RESULTS AND DISCUSSION

172 3.1 Comparison study of Lindedouble column and Linde-Frankl processes:

173 The processes are simulated in DWSIMsoftware, and various parameters are listed in the table
 174 below and compared based on operation feasibility and economic viability.

175 **Table 3:** Comparison of different simulation aspects of LD and LF processes

S No.	Aspect	Linde-double column process (LD)	Linde-Frankl process (LF)	Remarks
	Product Purity	N ₂ =99.988% O ₂ =99.9%	N ₂ =99.976% O ₂ =99%	LD (high purity)
	% Yield	N ₂ =99.72% O ₂ =87.74%	N ₂ =98.685% O ₂ =93%	LD N ₂ , being the main product, is recovered most
	Energy Generated	13797.8KW	12997.9KW	LD
	Purge Stream	153.131(Kmol/hr) N ₂ =0.06 O ₂ =0.68 Ar=0.26	133.57(Kmol/hr) N ₂ =0.314 O ₂ =0.445 Ar=0.241	LD Less N ₂ is being lost
	Amounts Obtained (Kmol/hr)	N ₂ =3185.15(99.988%) O ₂ =750.68(99.9%)	N ₂ =3152.24(99.976%) O ₂ =803.235(99%)	LD More N ₂ obtained
	Columns	2	2	LD
	Complexity	Less Complex	More Complex	LD

	Costs	Less	More (Due to complexity)	LD
	Ease of Control	Easy	Hard	LD
	Maintenance	Less	More (Due to more units)	LD
	Process	Low Pressure	High Pressure	LD
	Coolers	3	5	LD
	Compressors	1	2	LD
	Heat Exchangers	1	2	LD

Table 3 shows that compared to the Linde-Frankl method, the Linde double-column process gives better results in terms of product purity ($\text{LN}_2 = 99.988\%$ and $\text{LOX} = 99.9\%$), as well as a substantial LN_2 Nitrogen recovery. Reducing the amount of nitrogen gas in the purge stream is a top priority. Although LD's purge stream flow rate is larger, the concentration of N_2 in it is much lower (N_2 mole %age in purge stream = 0.059). This demonstrates a fast rate of recovery and a negligible amount of N_2 lost in the purge stream. Because fewer units were needed for the LD process, it was easier to manage, less expensive, and simpler. In spite of the fact that the LF method achieves higher oxygen recovery (93% vs. 87.74%), the LD process is simpler and more efficient throughout. For situations where nitrogen production, purity, and operational economy are of utmost importance, the LD technique is the superior alternative.

Table 4(a) & 4(b): Comparison of distillation columns (N_2 separator & O_2 separator)

parameters of LD and LF processes

4(a) Nitrogen separator:

S No.	Aspect	Linde-double column process(LD)	Linde-Frankl Process(LF)	Remarks
1	Stages	18	29	LD
2	Reflux	1.5	1.5	
3	N ₂ product flow rate (Kmol/hr)	3185.53(99.988%)	3152.54(99.976%)	LD
4	Reboiler duty (KW)	11308.58	10100	LF
5	Condenser duty (KW)	12253.67	10627.17	LF
6	Pressure (bar)	1.01325	5	LD
7	Estimated height (m)	11	15.5	LD

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192 **4(b)Oxygen separator:**

SNo.	Aspect	Linde-double column process (LD)	Linde-Frankl Process(LF)	Remarks
1	Stages	35	30	LF
2	Reflux	14	14	
3	Pressure (bar)	1.01325	2	LD
4	O ₂ product flow rate (Kmol/hr)	750.68	803.235	LF
5	Reboiler duty (KW)	4218.85	3278.19	LF
6	Condenser duty (KW)	4212.30	3437.17	LF
7	Waste stream (Kmol/hr)	153.31 N ₂ =0.07	133.57 N ₂ =0.314	LD(less N ₂ is being lost)

		O ₂ =0.63 Ar=0.30	O ₂ =0.445 Ar=0.241	
7	Estimated height (m)	23.5	16	LF

Table 4(a) compares the two processes, LD and LF, based on several features of the first distillation column, the N₂ separator. Number of stages, reflux ratio, heat duty, operating pressure, and column height are all quantities that should be kept to a minimum. To produce more high-purity liquid nitrogen in less time and with lower operating pressure, the Linde-double column technique is superior. This method also uses fewer stages.

According to **Table 4(b)** (O₂ separator), LF has been given the upper hand over LD in several areas of the secondary distillation column. In contrast to the LD method, which yields 99.9 % pure liquid oxygen, the LF process only produces O₂ with a purity of 99%. The LD technique also produces a much considerable output of liquid oxygen (yield=87.74%). The secondary distillation column works better with LF, however LD might produce more pure liquid oxygen and a greater amount. If large quantities of liquid oxygen are needed, LF is the only viable option when both simulations are taken into account, regardless of the cost. According to the results, LD is the most effective method for making very pure nitrogen and oxygen in liquid form.

3.2 Optimisation of the Linde double column process

After determining that Linde's double column was the most efficient method for producing both high-quantity and very pure liquid nitrogen and oxygen, an optimization study was conducted on the distillation columns of the LD process to further increase the purity of LN₂ and also to minimize the purge stream flow rate.

3.2.1 Effect of Number of Stages of primary column on Molar flow rate of Liquid Nitrogen and Purity

In order to determine how the purity and molar flow rate of Liquid Nitrogen were affected by the number of stages, the following graph was used. By looking at **Fig3**, the purity of the Liquid Nitrogen grows with the number of stages, although the flow rate drops significantly. Since 99.99 % pure liquid nitrogen is needed, this drop-in flow rate may be disregarded. The optimal number of phases was therefore determined to be 20.

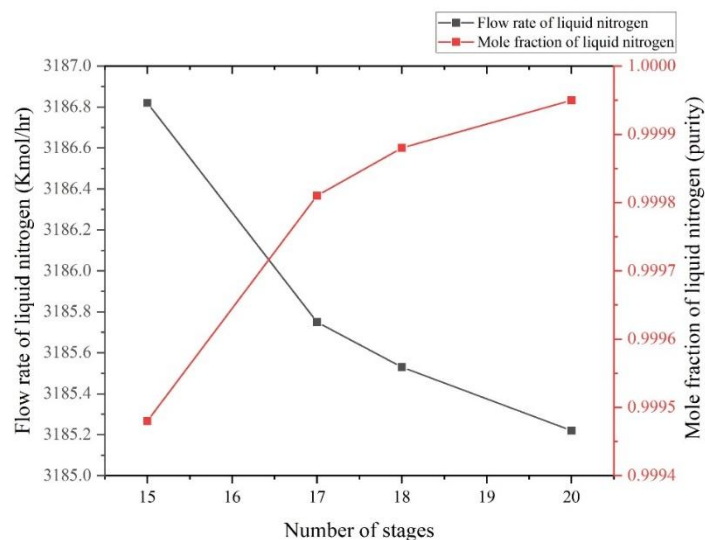


Fig 3: Effect of the number of stages of the primary column on molar flow rate and purity of LN_2

3.2.2 Effect of Reflux Ratio of primary column on Purity of Liquid Nitrogen

As the reflux ratio is one of the main parameters in the design of a distillation column, the optimum reflux ratio value is chosen based on maximum purity. From **Fig. 4**, initially as the reflux ratio increases mole fraction of Liquid Nitrogen rises sharply, and then the profile becomes flat on further increase of the value (as it is the maximum achievable separation). Therefore, a reflux ratio of 1.5 to 2 would be optimum. The optimal reflux ratio is 1.5, considering operational practicality and cost considerations, as the mole fraction of liquid nitrogen is more than 0.9999, indicating 99.99% purity.

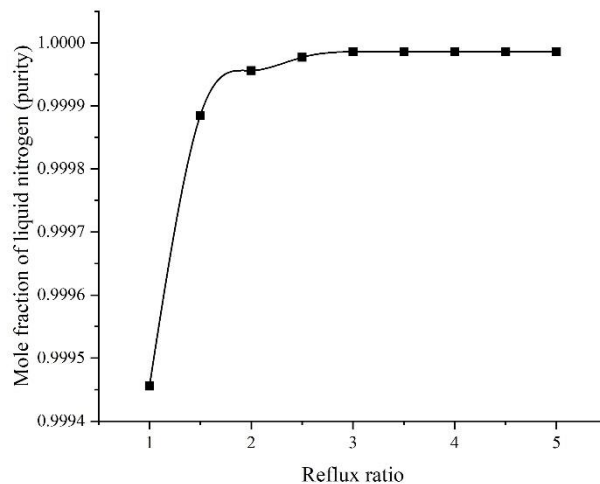


Fig 4: Effect of the reflux ratio of primary column on the purity of LN₂

3.2.3 Effect of Number of stages of secondary column on Molar Flowrate of Liquid Oxygen and purge stream flowrate

Due to the presence of a purge stream that must be minimized to avoid losses and the necessity to maximize the molar flow rate of the Liquid Oxygen stream, it is crucial to optimize the number of stages in the secondary column. The mole fraction of Liquid Oxygen is set at 0.999 (99.9% purity) due to process and operating difficulties; this number will remain constant regardless of the stages' increase or reduction. After considering column height and economic factors, 45 stages were determined to be the optimal for the secondary distillation column (**Fig. 5**). Under optimum conditions, the minimum purge stream flow rate was measured at 136.763 Kmol/hr, whereas the maximum liquid oxygen flow rate was 767.431 Kmol/hr. As a result, the liquid oxygen yield is increased to 89.7 %.

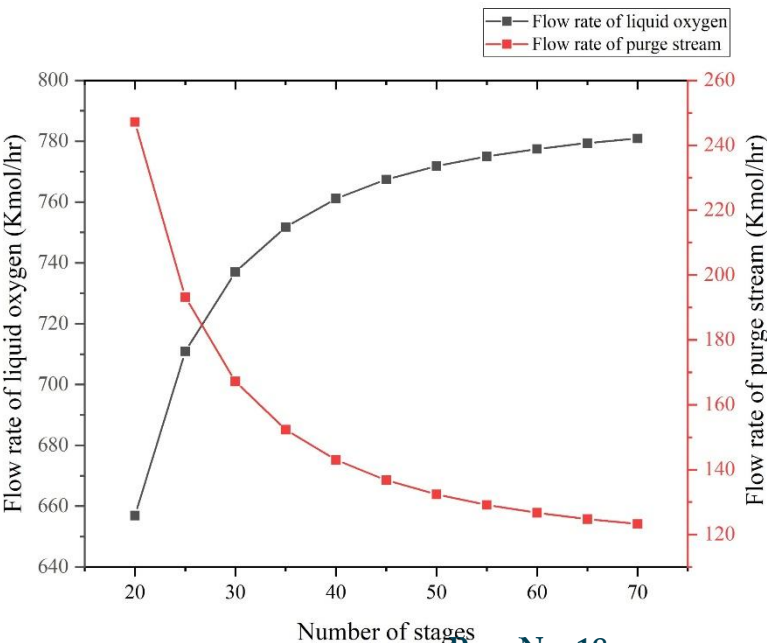


Fig 5: Effect of the number of stages on LOX flow rate and purge stream flow rate

3.2.4 Effect of the Reflux ratio of secondary column on the Flow rate of liquid oxygen:

Since the mixture entering the column mostly consists of oxygen and argon, a close-boiling-point combination, and since distillation makes full separation of its components very difficult, the secondary column includes a relatively high reflux ratio. Large reflux ratios are necessary to achieve maximum separation. **Fig 6** shows the fluctuation of the molar flow rate of oxygen as the reflux ratio increases, given that the purity of the liquid oxygen remains constant at 99.9%. With an ideal reflux ratio of 15, the liquid oxygen flow rate was further raised to 774.162 Kmol/hr, and the purge stream flow rate was lowered to 129.956 Kmol/hr. Since the yield is much better at 90.49%, this flow rate is selected as optimal.

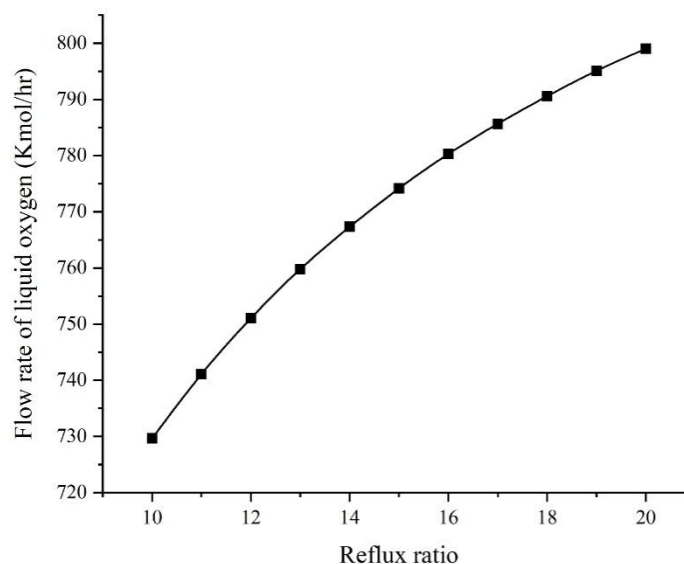


Fig 6: Effect of the reflux ratio of the secondary column on the LOX flow rate

Table 5: Optimized parameters of the Distillation columns

Distillation Column Parameters		Before optimization	After optimization
Primary Column	Number of stages	18	20
	Reflux ratio	1.5	1.5
Secondary Column	Number of stages	35	45
	Reflux ratio	14	15

After increasing the column parameters to optimum values as shown in **Table 5**, the liquid nitrogen purity is increased from 99.988% to 99.995%, the liquid oxygen flow rate is also increased from 750.68 Kmole/hr to 774.162 Kmole/hr, and the purge stream flow rate is reduced from 153.131 Kmole/hr to 129.956 Kmole/hr.

Conclusion:

This study used the Linde-Frankl and Linde double-column procedures to produce cryogenic fluids like liquid nitrogen and oxygen. Since the Peng-Robinson equation of state is more robust at cryogenic conditions, it was used as a thermodynamic model in the DWSIM software simulations of both processes.

After comparing the two processes, it was concluded that the LD process was more advantageous than the LF process due to its simplicity, product purity, and economic feasibility. The Linde double-column process, when operated under optimal conditions, reduced the purge stream flow rate to 129.956 Kmole/hr, which contains (7% nitrogen, 63% oxygen, and 30% oxygen), increased the liquid nitrogen purity to 99.995% and increased the liquid oxygen flow rate to 774.17 Kmole/hr (with a purity of up to 99.9%). The Linde double column simulation was designed to have a safety factor of 2.

According to the findings, the Linde double-column process outperforms other methods for large-scale cryogenic air separation at a reasonable cost while maintaining a high product purity. The optimization technique was shaped by using DWSIM, an open-source simulation tool, which was critical for understanding the process.

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Credit authorship contribution statement

SrideviVeluru&Paruchuri Sai Krishna Hemanth: Data curation, Methodology, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing. Pakalapati Jaya Salini: Conceptualization, Data curation, Methodology, Formal analysis, Investigation, Writing – original draft, Validation. MedamBalaVijaya Lakshmi: Conceptualization, Data curation, Methodology, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing., NekkalaAkashVeera Surya Vivek&PattasiSatwikVardhan,NunsavathuJayasree Bai: Investigation, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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