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Simulation and Thermodynamic Analysis of a Closed Cycle Nitrogen Expansion Process for Liquefaction of Natural Gas in Mini-scale

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ABSTRACT

In this study a closed nitrogen expansion cycle (Niche) has been simulated with Aspen HYSYS V8.4. Energy and exergy analysis were applied to evaluate the process. Results of energy analysis indicated that specific power consumption of this process is 0.68 kWh/kg LNG. The results of exergy analysis showed that exergy efficiency of Niche LNG is 35.51%. It is concluded there is an interaction between specific power consumption and exergetic efficiency. Moreover, the highest value of exergetic efficiency and irrevsibility belong to compressor (C3) and gas turbine (E1). Moreover, this process can be suitable for mini-scale LNG plants.

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1. Introduction

Among the methods exist for transportation of natural gas, liquefaction of natural gas is the most economical and simple because the occupied volume of liquefied natural gas is 600 times less than natural gas by cooling down it up to -162 °C at 1 bar. Basically, energy consumption of natural gas liquefaction processes shouldn't be more than a specified value because it won't be economical [1]. As well as, LNG demand is increasing about 6% every year [2]. For this purpose, some companies such as Mustang, ABB Lummus Global Inc. and Gasconsult improved the LNG processes through designing new heat exchangers or process configurations to reduce the energy consumption.

Totally, main refrigeration cycles for LNG production can be classified into three groups including: Cascade, Mixed refrigerant and Expansion cycles [3,4]. Generally, the Cascade processes, propane precooling mixed refrigerant (C3MR) and dual mixed refrigerant (DMR) cycles, are used for the base-load scales and the single mixed refrigerant (SMR) and nitrogen expansion cycles mainly used for the small scale LNG plants which have been compared in the different references [5,6,7,8]. Normally, SMR processes have higher efficiency compared with N_2-expansion cycles, but N_2 cycles are more simple and more safe processes [9,10].

There are several processes for liquefaction of natural gas with nitrogen expansion cycles such as OCX-R, NDX-1, OCX-2, Niche LNG, ZR LNG [10,11,12,13]. The most important parameter in all of these processes is energy consumption which can be calculated via energy analysis. With exergy analysis it will be determined where and how much energy is wasting through process [14]. Furthermore, an exergy analysis usually identifies which equipment have the maximum performance in the process and have the highest lost work [15].

Many investigations have been done for liquefaction of natural gas with Nitrogen expansion cycles which used thermodynamic analysis (energy and exergy) to investigate the performance of the processes. Remeljej and Hoadley [4] investigated four processes including single-stage mixed refrigerant (SMR), a two-stage expander nitrogen refrigerant and two open-loop expander processes in the steady state. They found that energy consumption of the SMR process is less than the other ones. However, nitrogen refrigerant process and the New LNG open-loop process are suitable for offshore compact LNG production. Yoan et al. [16] recommended a single stage nitrogen expansion process with carbon dioxide pre-cooling cycle for small scale LNG plants, then compared with propane pre-cooling, N_2-CH_4 expander cycle process and new mixed refrigeration cycle proposed by Cao et al. [6]. They concluded that this process is suitable for small scale LNG plants due to safe operation. He and Ju. [17] added two different precooling cycles including propane and R410a as a refrigerant to a nitrogen expansion liquefaction process to improve its performance. The results showed that the energy consumption for the nitrogen expansion process with R410a and propane reduced by 22.74% and 20.02% respectively, compared to the nitrogen expansion process without precooling. He and Ju [18] proposed a parallel nitrogen expansion liquefaction process for small scale plants in a skid mounted package. They showed that the energy consumption of the process is reduced approximately 4.69% compared to the conventional nitrogen expansion processes. Moein et al. [19] investigated the effect of the methane addition on a dual nitrogen expansion cycles for LNG production. They concluded that the work consumption of the process will be minimized when the concentration of the methane in the refrigerant is equal to 26 ± 1 mol% in which the net required work of the process is 8% less compared to the optimized case of the process with pure nitrogen as a refrigerant. Palizdar et al [20] applied energy, conventional, and advanced exergy analysis to three mini scale nitrogen expansion for LNG production including: APN, Statoil and

BHP Nitrogen expansion process. Results of conventional exergy analysis indicated that air coolers have a high irreversibility and have a small exergy efficiency. Also, results of energy analysis showed that APN process has the least energy consumption compared with other processes (approximately 85%). Results of advanced exergy analysis showed that for all of these processes, exergy destruction of the air coolers is unavoidable. Furthermore, a high portion of total avoidable exergy destruction of the processes (up to 85%) belongs to compressors and expanders.

However, among the works have been done for LNG production with expansion processes and some of them were mentioned in above, there are several nitrogen expansion processes that have not been investigated yet, such as open and closed nitrogen expansion cycle processes. In this study, a closed nitrogen expansion cycle (Niche) has been simulated. The studied process is invented by ABB Lummus Global Inc company [21]. Then, thermodynamic analysis was applied to this process including energy and exergy analysis. In energy analysis some parameters such as SPC and COP will be calculated and T-s and P-h diagrams are plotted. Moreover, in exergy analysis it is determined which equipment has the highest exergetic efficiency and irreversibility.

2. Process Description

The process flow diagram has been illustrated in Figure 1, schematically. As shown, the process consists of two independent refrigerant cycles. The first cycle uses methane as refrigerant and the second cycle uses nitrogen. The pre-treated natural gas stream (20) at 35 °C and 60 bar enters LNG heat exchanger (75-LNG) and is cooled to -121.54 °C (20-1). The cooled natural gas (20-1) enters LNG heat exchanger (75-1 LNG) and is cooled further to -152.60 °C, approximately (22). The pressure of the cooled natural gas (22) is decreased from 58.75 to 1.35 bar via an expansion valve and its temperature decreases to -161.31 °C (24). The expanded liquefied natural gas (24) enters a flash tank where LNG and flash gas is separated [21,22].

In the first refrigerant cycle with methane as a refrigerant, expanded methane (44) enters LNG heat exchanger (75-LNG) at -127.10 °C and 6.90 bar and exchanges heat with both inlet natural gas stream (20) and methane refrigerant inlet stream (40), then exits LNG heat exchanger (75-LNG) at 36.86 °C (46). The warmed methane refrigerant (46) is partially compressed in the first compressor (C1) from 6.40 to 21.50 bar and is cooled to 40 °C in the first air cooler (AC1). The partially compressed and cooled methane is then compressed in the second compressor (C2) from 21.40 to 76.53 bar and cooled to 40 °C in the second air cooler (40). Stream 40 is the starting point of the methane refrigerant cycle and enters LNG heat exchanger (75-LNG) at 40 °C and 76.43 bar and cooled in LNG heat exchanger (75-LNG) to -18 °C (42). The cooled methane refrigerant (42) is reduced in pressure by expansion in the expander (E-1) from 75.93 to 6.90 bar and its temperature decreases to -127.10 °C (44). Stream 44 is returned to the LNG heat exchanger (75-LNG) and the cycle is repeated as mentioned above.

In the second refrigerant cycle with nitrogen as the refrigerant, expanded nitrogen (34) at -155 °C and 15bar enters LNG heat exchanger (75-1-LNG) and exchanges heat with precooled natural gas (20-1) and inlet stream of nitrogen refrigerant (30) and exits LNG heat exchanger (75-1-LNG) at 25.58 °C (36). The warmed nitrogen refrigerant (36) is first compressed in the first compressor (C3) from 14.25 to 37.25 bar and cooled to 40 °C in the first air cooler (AC3) then compressed in the second compressor from 37.15 to 80.10 bar and cooled to 40 °C in the second air cooler (AC4). Stream 30 enters LNG heat exchanger (75-1-LNG) at 40 °C and 80 bar, is cooled to -88 °C (32), expanded in expander (E2) from 79.5 to 15 bar and its temperature decreases to -155 °C (stream 34) and the cycle is repeated as mentioned above. Mass flow rate of methane and nitrogen as refrigerant are 1650 kg/hr and 1350 kg/hr, respectively.

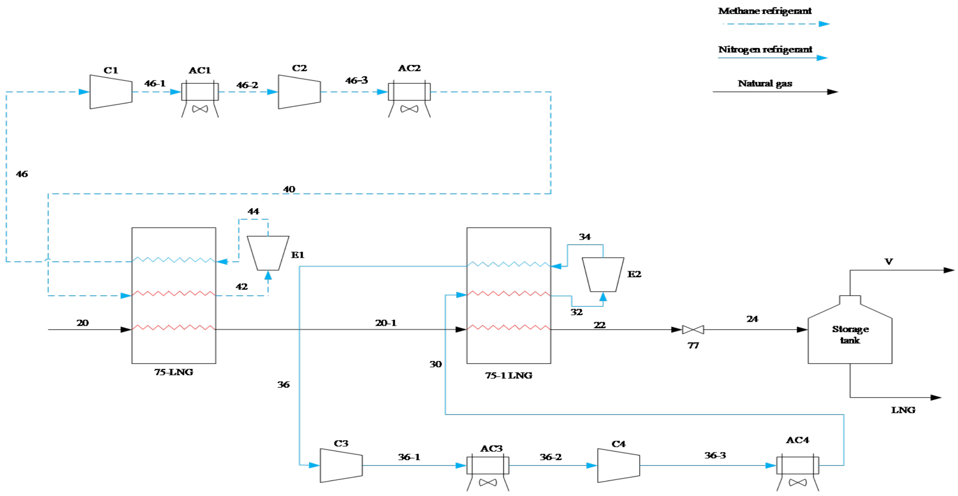


Figure 1. Process flow diagram of Niche LNG process

3. Simulation

A closed cycle nitrogen expansion process is simulated by Aspen HYSYS software (V.8.4) in steady state which have been successfully used by the other researchers. The first step and the most important part of the simulation of a process is choosing an accurate property method. Peng Robinson (PR) equation of state has been selected for simulating of the liquefaction processes which have been previously used and validated for the liquefaction processes [23, 24]. Some assumptions have been applied to simplify the processes which have been mentioned in Table 1. The specifications of feed gas and LNG production streams have been listed in Table 2.

Table 1. Assumptions of operating and theoretical conditions for the process components.

Component		Operating conditions	Theoretical conditions
Compressor	η (%)	75	100
Expander	η (%)	75	100
Heat Exchanger	ΔTmin (ºC)	> 2	0
Air Cooler	Pressure drop (bar)	0.1	0

Table 2. Specifications of the feed gas and LNG product streams for Niche LNG process

	Feed gas [20]	LNG stream
Mass Flow (kg/hr)	470.00	425.40
Temperature (ºC)	35.00	-161.31
Pressure (bar)	60.00	1.35
Molar Enthalpy (kJ/kmol)	-73534.18	-89455.00
Components (%mol)		
CH_4	92.94	94.72
C_2H_6	3.00	3.28
C_3H_8	0.48	0.52
i-C_4H_{10}	0.06	0.07
n-C_4H_{10}	0.08	0.09
N_2	3.44	1.33

The operational conditions of simulated process including temperature, pressure, mass flow and total exergy for material streams have been illustrated in Table 3.

Table 3. operational conditions for material streams

Stream name	Temperature (°C)	Pressure (bar)	Mass Flow (kg/h)	Total exergy (kW)
20	35	60	470	74.99
20-1	-121.54	59.25	470	112.41
22	-152.58	58.75	470	129.01
24	-161.31	1.35	470	124.48
30	40	80	1350	144.18
32	-88	79.5	1350	159.24
34	-155	15	1350	131.91
36	25.58	14.25	1350	87.63
36-1	149.92	37.25	1350	125.68
36-2	40	37.15	1350	119.09
36-3	141.16	80.1	1350	150.43
40	40	76.43	1650	295.36
42	-18	75.93	1650	299.09
44	-127.1	6.9	1650	200.83
46	36.86	6.4	1650	127.39
46-1	159.43	21.5	1650	236.28
46-2	40	21.4	1650	211.23
46-3	171.58	76.53	1650	324.17
LNG	-161.31	1.35	425.4	121.06
V	-161.31	1.35	44.6	2.68

4. Analysis of Process

4.1. Energy Analysis

Energy analysis of a closed cycle Nitrogen expansion process has been done to calculate the specific power consumption (SPC) and coefficient of performance (COP) of the cycle.

SPC is defined as the total power consumed in the whole process divided by the mass flow rate of the produced LNG [25].

$$\mathrm{SPC} = \frac{\text{Total required power in the whole process (kW)}}{\text{Mass flow rate of LNG (kg/hr)}}$$

and COP is defined as:

$$\mathrm{COP} = \frac{\text{Total removed heat from natural gas (kW)}}{\text{Total required power in compressors (kW)}}$$

Also, deviation of real conditions refrigerant cycles from the ideal state are compared in pressure-enthalpy and temperature-entropy diagrams.

4.2. Exergy analysis

Exergy is defined as the maximum work that obtains from a process [25]. The total exergy rate of the material stream is defined as summation of the potential exergy, kinetic exergy, chemical exergy and physical exergy. Potential and kinetic exergy are negligible in these processes, so total exergy defined as [20]:

$$\dot{E} = \dot{E}^{ph} + \dot{E}^{ch} \tag{1}$$

$$\dot{E}^{ph} = \dot{H} - \dot{H}_0 - T_0\left(\dot{S} - \dot{S}_0\right) \tag{2}$$

where $\dot{H}$ and $\dot{S}$ are enthalpy and entropy rates of the stream at initial temperature and pressure and $\dot{H}_0$ and $\dot{S}_0$ are standard enthalpy and entropy rates of the stream at environment temperature (T_0) and pressure. Chemical exergy ($\dot{E}^{ch}$) is defined as [4]:

$$\dot{E}^{ch} = \sum x_i \dot{E}_i^0 + \dot{G} - \sum x_i \dot{G}_i \tag{3}$$

where x_i is the mole fraction of i^{th} component in the stream, $\dot{E}_i^0$ is the standard chemical exergy rate of i^{th} component, $\dot{G}$ is rate of Gibbs free energy of the stream and $\dot{G}_i$ is rate of Gibbs free energy of pure i^{th} component at T_0 and P_0.

After calculating of the total exergy for the material streams, exergy balance must be applied to each component to determine two important parameter in exergy analysis including: exergy efficiency and exergy destruction.

After determining the total exergy of process streams, exergy balance must be written for each component in order to calculate exergy efficiency and exergy destruction. The equations of exergy efficiency and exergy destruction for each component are summarized in Table 4.

Table 4. The equations of exergy efficiency and exergy destruction for each component [20]

Table 4. The equations of exergy efficiency and exergy destruction for each component [20]

Component	Exergy destruction	Exergetic efficiency
Compressor	$\dot{W}_{Comp} - \dot{E}x_{out} + \dot{E}x_{in}$	$(\dot{E}x_{out} - \dot{E}x_{in}) / \dot{W}_{Comp}$
Expander	$\dot{E}x_{in} - \dot{E}x_{out} - \dot{W}_{Exp}$	$\dot{W}_{Exp} / (\dot{E}x_{in} - \dot{E}x_{out})$
Heat exchanger	$\sum(\dot{E}x_{in} - \dot{E}x_{out})_{Cold} - \sum(\dot{E}x_{out} - \dot{E}x_{in})_{Hot}$	$\sum(\dot{E}x_{out} - \dot{E}x_{in})_{Hot} / \sum(\dot{E}x_{in} - \dot{E}x_{out})_{Cold}$
Air Cooler	$\dot{E}x_{in} - \dot{E}x_{out} - \dot{E}_{out}^{air}$	$\dot{E}_{out}^{air} / (\dot{E}x_{in} - \dot{E}x_{out})$
Total system	Summation of irreversibility of all devices	$\epsilon = 1 -$ (Summation of irreversibility of all devices $/ \sum \dot{W}_{Comp}$)

5. Results and Discussion

5.1. Energy analysis

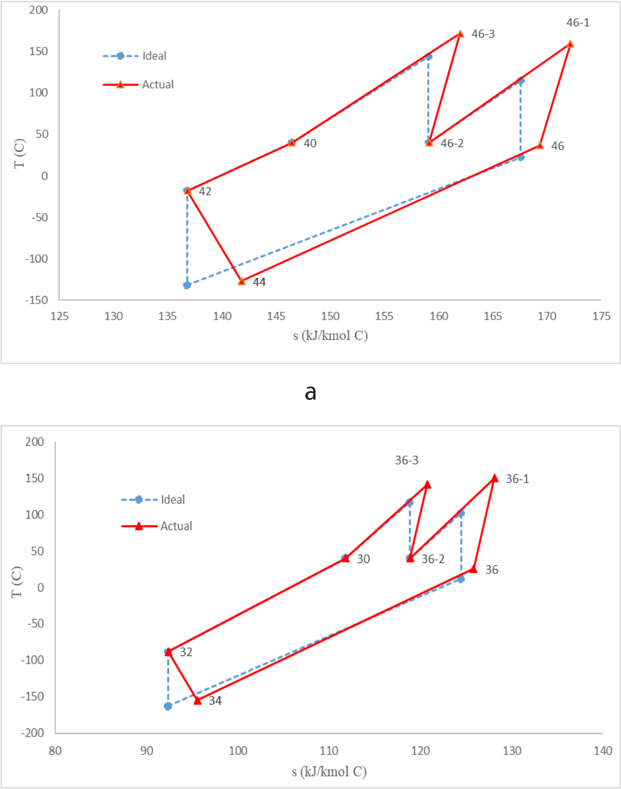
Results of energy analysis are shown in table 5, 6, respectively. Specific power consumption of this process (SPC) was calculated 0.68 kWh/kg LNG. This value is approximately close to the literature [26] which confirms almost 0.70 kWh/kg LNG for SPC of dual stage nitrogen expansion processes. In addition, as it can be seen in table 6, pre-cooling cycles coefficient of performance are higher than the other ones due to proximity of hot and cold streams in heat exchanger of these processes the values of COP for nitrogen and methane cycle is 0.42 and 0.19 respectively. Furthermore, the total removed heat from natural gas including latent and sensible heat is 103.60 kW.

Table 5. The value of SPC for liquefaction processes

	Niche LNG
Total power consumption in compressors (kW)	365.36
Total produced power in expanders (kW)	75.04
Overall power (kW)	290.32
Mass flow rate of LNG production (kg/h)	425.40
SPC (kWh/kg LNG)	0.68

Table 6. Consumed power, removed heat and coefficient of performance for the cycles

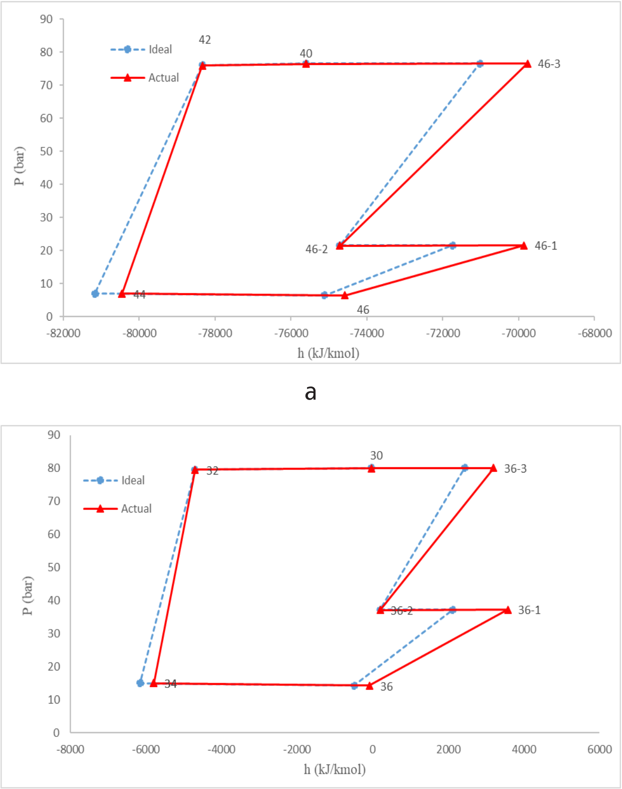
Process	Cycle	Total required power (kW)	Cold duty (kW)	COP
Niche LNG	Methane	215.75	89.69	0.42
	Nitrogen	74.57	13.91	0.19



a

b

Figure 2: T-s diagrams for Niche LNG process a: Methane cycle b: Nitrogen cycle



a

b

Figure 3: P-h diagrams for Niche LNG process a: Methane cycle b: Nitrogen cycle

The temperature - entropy (*T-s*) and pressure - enthalpy (*P-h*) diagrams for the ideal and actual liquefaction cycles are shown in Figures. 2,3. As seen, the deviation of nitrogen cycle is less than methane cycle.

Table 7 shows the thermodynamic performance of main components of the liquefaction cycles.

Table 7. Thermodynamic performance of the components.

A: Heat exchangers

Component	Duty (kW)	Min. approach (°C)	LMTD (°C)
75-LNG	167.71	3.14	14.16
75-1-LNG	76.40	2.43	12.29

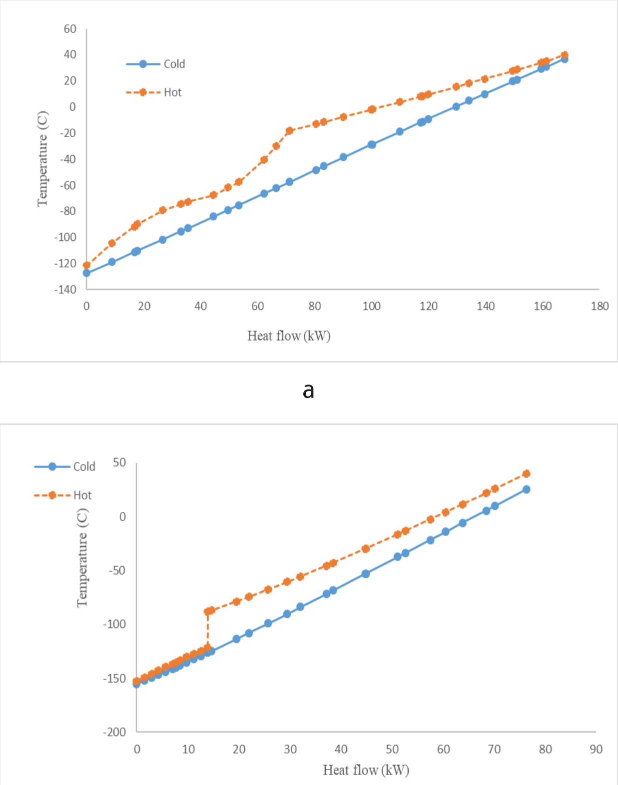
B: Compressors

Component	Power consumed (kW)	Adiabatic efficiency (%)	Pressure ratio	Outlet temperature (°C)
C1	134.87	75.00	3.36	159.43
C2	141.32	75.00	3.58	171.58
C3	49.03	75.00	2.61	149.92
C4	40.13	75.00	2.16	141.16

C: Expanders

Component	Power produced (kW)	Adiabatic efficiency (%)	Pressure ratio	Outlet temperature (°C)
E1	60.45	75.00	0.09	-127.10
E2	14.59	75.00	0.19	-155.00

Figure 4. indicates composite curves for heat exchangers of Niche LNG process. For all of the air coolers, the specifications of inlet air were considered 25 °C and 1 atm.



a

b

Figure 4. Composite curves of 75- LNG (a) and 75-1-LNG (b) Heat exchangers for Niche LNG process.

5.2. Exergy analysis

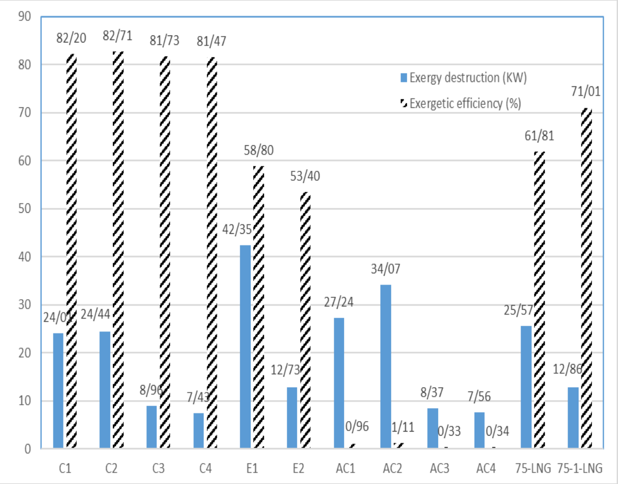


Figure 5. Results of exergy analysis for Niche LNG process

Results of exergy analysis have been illustrated in Figure 5. Both of exergy analysis parameters including exergy destruction and exergy efficiency have been calculated with equations of table3. As shown in Figure 6. the highest exergy destruction and exergetic efficiency are for expander E-1 and compressor C-2. Additionally, total exergy destruction rate and exergetic efficiency of Niche LNG process are 235.61 kW and 35.51%, respectively.

6. Conclusionsn

In this paper a closed nitrogen expansion cycle has been simulated with Aspen HYSYS V8.4. two thermodynamic analysis including: energy and exergy analyses were applied to this process to evaluate this process, operational. Results of energy analysis indicated that specific power consumption of this process is 0.68 kWh/kg LNG. The results of exergy analysis showed that exergy efficiency and exergy destruction rate of Niche LNG process are 35.51% and 235.61 kW, respectively. It is concluded that there is an interaction between specific power consumption and exergetic efficiency. Moreover, the highest value of exergetic efficiency and irrevsibility belong to compressor (C3) and gas turbine (E1). Also, this process can be suitable for mini-scale LNG plants.

7. References

1. A. Alabdulakram, A. Mortazavi, C. Somers, Y. Hwang, R. Radermacher, P. Rodgers, and S. Al-Hashimi, "Performance enhancement of propane pre-cooled mixed refrigerant LNG plant," Appl. Energy, vol. 93, no. 6-7, pp. 125-131, 2011.

2. Axens. IFP group technology, "Liquefying technical brochure," 2002.

3. K. D. Venkatarathnam, G. and Timmerhaus, Cryogenic mixed refrigerant processes. New York: Springer, 2008.

4. C. W. Remeljej and A. F. A. Hoadley, "An exergy analysis of small-scale liquefied natural gas (LNG) liquefaction processes," Energy, vol. 31, no. 12, pp. 1669-1683, 2006.

5. L. Castillo and C. A. Dorao, "Influence of the plot area in an economical analysis for selecting small scale LNG technologies for remote gas production," J. Nat. Gas Sci. Eng., vol. 2, no. 6, pp. 302-309, 2010.

6. W. S. Cao, X. S. Lu, W. S. Lin, and A. Z. Gu, "Parameter comparison of two small-scale natural gas liquefaction processes in skid-mounted packages," Appl. Therm. Eng., vol. 26, no. 8-9, pp. 898-904, 2006.

7. Gas today, "Developing Small-scale LNG Plants," 2010.

8. C. Wensheng, "Natural gas liquefaction process for small-scale LNG project. In Computer Distributed Control and Intelligent Environmental Monitoring (CDCIEM)," 2012, pp. 439-442.

9. H. M. Chang, M. J. Chung, M. J. Kim, and S. B. Park, "Thermodynamic design of methane liquefaction system based on reversed-Brayton cycle," Cryogenics (Guildf)., vol. 49, no. 6, pp. 226-234, 2009.

10. S. Pérez and R. Díez, "Opportunities of Monetising Natural Gas Reserves Using Small To Medium Scale Lng Technologies," 2009.

11. H.B.Walther S, Franklin D, Ross P, "Liquefaction Solutions for Challenge of New Offshore Fpso Developments," LNG journal. Mustang Eng. Houst., vol. 4, 2008.

12. International Gas Union (I.G.U.), "Small Scale LNG," 2015.

13. B. Howe and G. Skinner, "ZR-LNG TM Dual Expander Methane Cycle Liquefaction Technology Applied to FLNG Authors ZR-LNG TM Dual Expander Methane Cycle Liquefaction Technology Applied to FLNG Introduction Design Perspectives for LNG Liquefaction Technologies."

14. M. A. Ansarinasab H, Mehrpooya M, "Advanced exergy and exergoeconomic analyses of a hydrogen liquefaction plant equipped with mixed refrigerant system," J. Clean. Prod., vol. 52, no. 144, pp. 248-259, 2017.

15. [15]T. He and Y. Ju, "Optimal synthesis of expansion liquefaction cycle for distributed-

scale LNG (liquefied natural gas) plant," Energy, vol. 88, pp. 268-280, 2015.

16. Z. Yuan, M. Cui, Y. Xie, and C. Li, "Design and analysis of a small-scale natural gas liquefaction process adopting single nitrogen expansion with carbon dioxide pre-cooling," Appl. Therm. Eng., vol. 64, no. 1-2, pp. 139-146, 2014.
17. T. B. He and Y. L. Ju, "Performance improvement of nitrogen expansion liquefaction process for small-scale LNG plant," Cryogenics (Guildf)., vol. 61, pp. 111-119, 2014.
18. T. He and Y. Ju, "A novel conceptual design of parallel nitrogen expansion liquefaction process for small-scale LNG (liquefied natural gas) plant in skid-mount packages," Energy, vol. 75, pp. 349-359, 2014.
19. P. Moein, M. Sarmad, M. Khakpour, and H. Delaram, "Methane addition effect on a dual nitrogen expander refrigeration cycle for LNG production," J. Nat. Gas Sci. Eng., vol. 33, pp. 1-7, 2016.
20. A. Palizdar, T. Ramezani, Z. Nargessi, S. AmirAfshar, M. Abbasi, and A. Vatani, "Thermodynamic evaluation of three mini-scale nitrogen single expansion processes for liquefaction of natural gas using advanced exergy analysis," Energy Convers. Manag., vol. 150, no. April, pp. 637-650, 2017.
21. F. J.H., "LNG Production Using Dual Independent Expander Refrigeration Cycles," US Patent 6412302B1, 2002.
22. S. S. Pwaga, "Sensitivity Analysis of Proposed LNG liquefaction Processes for LNG FPSO," no. July, 2011.
23. M. S. Khan, S. Lee, M. Getu, and M. Lee, "Knowledge inspired investigation of selected parameters on energy consumption in nitrogen single and dual expander processes of natural gas liquefaction," J. Nat. Gas Sci. Eng., vol. 23, no. March 2000, pp. 324-337, 2015.
24. H. Ding, H. Sun, and M. He, "Optimisation of expansion liquefaction processes using mixed refrigerant N2-CH4," Appl. Therm. Eng., vol. 93, pp. 1053-1060, 2016.
25. A. Vatani, M. Mehrpooya, and A. Palizdar, "Advanced exergetic analysis of five natural gas liquefaction processes," Energy Convers. Manag., vol. 78, pp. 720-737, 2014.
26. T. Kuru and E. T. Iyagba, "Optimization of Natural Gas Liquefaction Processes for Offshore Floating Liquefied Natural Gas Plants," Int. J. Sci. Eng. Investig., vol. 2, no. 21, pp. 34-39, 2013.

شبیه‌سازی و تحلیل ترمودینامیکی فرآیند انبساطی نیتروژن چرخه بسته برای مایع-سازی گاز طبیعی در مقیاس کوچک

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چکیده

در این پژوهش، یک چرخه انبساطی نیتروژن بسته (Niche) با استفاده از نرم‌افزار Aspen HYSYS V8.4 شبیه‌سازی گردیده است. به‌منظور ارزیابی فرآیند مذکور از تحلیل‌های انرژی و اکسرژی استفاده شده است. نتایج حاصل از تحلیل انرژی نشان داد که میزان توان ویژه مصرفی این فرآیند برابر ۰/۶۸ kWh/kg LNG می‌باشد. نتایج حاصل از تحلیل اکسرژی نیز نشان داد که راندمان اکسرژی فرآیند Niche LNG برابر ٪۳۵/۵۱ است. نتیجه حاصل از این دو تحلیل تعامل بین توان ویژه مصرفی و راندمان اکسرژی بود. علاوه بر این، بالاترین مقدار راندمان و اتلاف اکسرژی، به‌ترتیب متعلق به کمپرسور C3 و توربین گازی E1 است. همچنین می‌توان گفت این فرآیند برای واحدهای مقیاس کوچک LNG می‌تواند گزینه مناسبی است.

واژگان کلیدی: چرخه انبساطی نیتروژن بسته ، تحلیل اکسرژی، توان ویژه مصرفی، گاز طبیعی مایع (LNG)