Data Article

Data on conceptual design of cryogenic energy storage system combined with liquefied natural gas regasification process

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Abstract

This paper describes data of an integrated process, cryogenic energy storage system combined with liquefied natural gas (LNG) regasification process. The data in this paper is associated with the article entitled “Conceptual Design and Exergy Analysis of Combined Cryogenic Energy Storage and LNG Regasification Processes: Cold and Power Integration” (Lee et al., 2017) [1]. The data includes the sensitivity case study dataset of the air flow rate and the heat exchanging feasibility data by composite curves. The data is expected to be helpful to the cryogenic energy process development.

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Specifications Table

| Subject area | Chemical Engineering |
|--------------|----------------------|
| More specific subject area | Process Systems Engineering |
| Type of data | Figures and Tables |
| How data was acquired | Through the computational process simulation by software, Aspen HYSYS |
| Data format | Filtered and analyzed |
| Experimental factors | Air flow rate, heat exchanging feasibility |

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Experimental features
Feasibility check, sensitivity analysis, performance evaluation

Data source location
Department of Chemical and Biomolecular Engineering, Yonsei University, Republic of Korea

Data accessibility
Data with this article

Value of the data
- The increase of the air flow rate causes increase of the power generation.
- The increase of the air flow rate causes decrease of the minimum temperature difference of the heat exchanger.
- The pinch point can be shown not only at the inlet or outlet but also inside the heat exchanger when the phase changing occurs.

1. Data

In this data article, we share sensitivity analysis data of the cryogenic energy storage system combined with liquefied natural gas (LNG) regasification process. In this data, the case study simulation results by air flow rate and the heat exchanging composite curves are illustrated.

2. Experimental design, materials and methods

2.1. Sensitivity analysis of the air flow rate

The air is used as the working fluid in this integrated energy storage system. To find the optimal flow rate of the air, the simulation case study is performed by the air flow rate for the sensitivity analysis. The flow rate of the LNG is fixed as 1.00 kg/s for every case. We set five cases of the air flow rate as follows: Case 1 is 0.40 kg/s, Case 2 is 0.45 kg/s, Case 3 is 0.50 kg/s, Case 4 is 0.55 kg/s and Case 5 is 0.60 kg/s of air flow rate. The specific work output of the cryogenic energy release system by the air flow rate is shown in Table 1. The stream notations are shown in Fig. 2 in Ref. [1].

The simulation result shows that the total work output is almost linear to the air flow rate.

2.2. Feasibility analysis for the heat exchangers

The detailed heat exchanging simulations are performed to check the feasibility and the results are shown in Table 2. The pinch temperature is set as 3 °C for every heat exchanger as the constraint. Therefore, the minimum temperature difference of the heat exchanger have to be larger than 3 °C. Finding pinch point is an important part in the procedure of the heat exchanging feasibility check. The hot stream is air and the cold stream is LNG for all heat exchangers. The cold LNG is vaporized via

| Specific work output         | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|------------------------------|--------|--------|--------|--------|--------|
| Air expander 1               | 30.23  | 34.01  | 37.79  | 41.57  | 45.35  |
| Air expander 2               | 31.98  | 35.97  | 39.97  | 43.97  | 47.97  |
| Air expander 3               | 33.27  | 37.42  | 41.58  | 45.74  | 49.90  |
| Air expander 4               | 33.26  | 37.42  | 41.58  | 45.74  | 49.89  |
| Total work output            | 128.74 | 144.82 | 160.92 | 177.02 | 193.11 |
heat exchange with air, from HX1 to HX5. On the other hand, the air flows into HX5, then passes HX4, HX3, HX2, and HX1 successively. The air is pressurized between the heat exchangers and liquefied by HX5. Thus, the phase changing is occur inside the HX5.

For the HX2, HX3, HX4, and HX5, heat is transferred from the vapor phase air to the liquid phase LNG. On the other hand, the vapor air is liquefied by the HX1, thus the phase change occurs inside the heat exchanger. The heat exchanging simulation results represent that the pinch points are shown in hot stream outlet of the heat exchanger when the phase does not change. However, the pinch point can be shown not only inlet or outlet but also inside the heat exchanger when the phase changing occurs. It can be well illustrated by the composite curve which is the heat flow to the temperature diagram. The composite curves for heat exchanging are one of the most efficient tools for chemical processes, especially for the heat exchanging dominant processes [2]. The detailed composite curves of the Case 3 are shown in Fig. 1. Note that, the Case 3 is the baseline case of the Ref. [1].

Fig. 2 illustrates the heat exchanger with phase changing, HX1, for every case. For the Case 4 and the Case 5, the hot stream temperatures are higher than cold stream temperatures at the inlet and the outlet of the heat exchangers. However, the temperature crosses are occurred inside the heat exchangers.

The temperature crosses are shown inside the heat exchangers for Case 4 and Case 5.

| Case  | HX1 | HX2 | HX3 | HX4 | HX5 |
|-------|-----|-----|-----|-----|-----|
| hot inlet side ΔT (K) | 86.1 | 63.8 | 120.5 | 108.4 | 97.3 |
| hot outlet side ΔT (K) | 12.5 | 15.1 | 15.9 | 9.5 | 5.2 |
| Minimum ΔT (K) | 12.5 | 15.1 | 15.9 | 9.5 | 5.2 |
| Pinch point | Hot stream outlet | Hot stream outlet | Hot stream outlet | Hot stream outlet | Hot stream outlet |

| Case 2 | HX1 | HX2 | HX3 | HX4 | HX5 |
|-------|-----|-----|-----|-----|-----|
| 74.3 | 85.8 | 106.4 | 95.2 | 94.0 |
| 12.5 | 12.8 | 14.1 | 7.8 | 3.4 |
| 12.5 | 12.8 | 14.1 | 7.8 | 3.4 |
| Pinch point | Hot stream outlet | Hot stream outlet | Hot stream outlet | Hot stream outlet | Hot stream outlet |

| Case 3 | HX1 | HX2 | HX3 | HX4 | HX5 |
|-------|-----|-----|-----|-----|-----|
| 66.6 | 51.5 | 96.8 | 86.3 | 92.5 |
| 12.5 | 12.9 | 14.5 | 8.2 | 3.6 |
| 9.8 | 12.9 | 14.5 | 8.2 | 3.6 |
| Pinch point | Heat exchanger inside | Hot stream outlet | Hot stream outlet | Hot stream outlet | Hot stream outlet |

| Case 4 | HX1 | HX2 | HX3 | HX4 | HX5 |
|-------|-----|-----|-----|-----|-----|
| 54.1 | 41.4 | 82.4 | 72.5 | 84.8 |
| 6.3 | 6.4 | 8.1 | 1.9 | −2.7 |
| −5.9 | 6.4 | 8.1 | 1.9 | −2.7 |
| Pinch point | Infeasible | Hot stream outlet | Hot stream outlet | Hot stream outlet | Infeasible |

| Case 5 | HX1 | HX2 | HX3 | HX4 | HX5 |
|-------|-----|-----|-----|-----|-----|
| 42.1 | 31.2 | 68.5 | 59.2 | 76.4 |
| 0.3 | −0.9 | 0.9 | −5.2 | −9.8 |
| −19.8 | −0.9 | 0.9 | −5.2 | −9.8 |
| Pinch point | Infeasible | Infeasible | Hot stream outlet | Infeasible | Infeasible |
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Fig. 1. Composite curves for the Case 3: (a) HX1, (b) HX2, (c) HX3, (d) HX4, and (e) HX5.

Fig. 2. Composite curves for the HX1: (a) Case 1, (b) Case 2, (c) Case 3, (d) Case 4, and (e) Case 5.
Supplementary material

Transparency document associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2017.09.015.

References

[1] I. Lee, J. Park, I. Moon, Conceptual design and exergy analysis of combined cryogenic energy storage and LNG regasification processes: cold and power integration, Energy (2017). http://dx.doi.org/10.1016/j.energy.2017.08.054.
[2] I. Lee, I. Moon, Economic optimization of dual mixed refrigerant liquefied natural gas plant considering natural gas extraction rate, Ind. Eng. Chem. Res. 56 (2017) 2804–2814. http://dx.doi.org/10.1021/acs.iecr.6b04124.