Performance enhancement of natural gas liquefaction (LNG) processes

***Muhammad Abdul* Qyyum**[1] **and *Moonyong* Lee**[1,*]

[1] **Yeungnam University,** School of Chemical Engineering, Gyeongsan 712-749, Republic of Korea.
*Correspondence Id: mynlee@ynu.ac.kr

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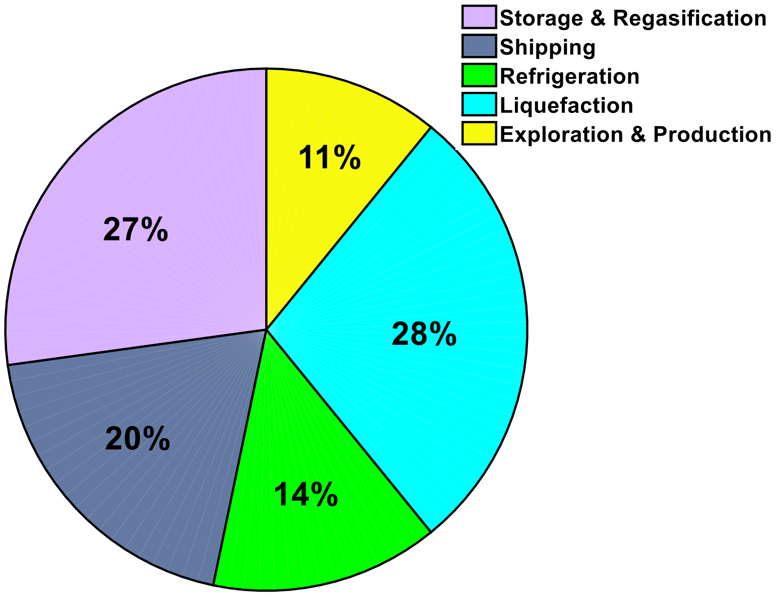
LNG Value Chain

- Generally, LNG value chain (also known as supply chain) consist of:
  - Exploration
  - Production
  - liquefaction & refrigeration
  - Shipping
  - Regasification and storage.



(Source: IGU world LNG report 2017)

- It is clear from this figure that around 42% of the total LNG project cost accounts for only liquefaction and refrigeration.

The major issue associated with LNG plants

"Low energy efficiency"

Why?

- The primary sources of inefficiency in real Refrigeration cycle are:

- ✓ Friction in the compressors
- ✓ Finite delta T in Hex
- ✓ Irreversible flashes across throttling valve (Isenthalpic expansion)
- ✓ Heat loss to the surroundings.

Therefore,

- Any small improvement in the performance of LNG process is increased the process global competitiveness and also enhance the economic benefits in terms of low energy consumption.

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Journal of Natural Gas Science and Engineering

Volume 34, August 2016, Pages 958-968

Effects of varying the ambient temperature on the performance of a single mixed refrigerant liquefaction process

Kyungtae Park [a], Wangyun Won [b], Dongil Shin [c]

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Applied Thermal Engineering

Available online 24 August 2017

In Press, Accepted Manuscript — Note to users

Research Paper

Feasibility study of environmental relative humidity through the thermodynamic effects on the performance of natural gas liquefaction process

Muhammad Abdul Qyyum[a], Le Quang Minh[a], Wahid Ali[a], Arif Hussain[a], Alireza Bahadori[b], Moonyong Lee[a]

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https://doi.org/10.1016/j.applthermaleng.2017.08.090

Highlights

- Effects of relative humidity on the performance of SMR was investigated successfully.
- Compression energy for SMR process was reduced significantly.
- Compression power has a linear relation with the relative humidity.
- The UA value of LNG cryogenic exchanger increases as 4th-order polynomial function.

l energy intensive process.

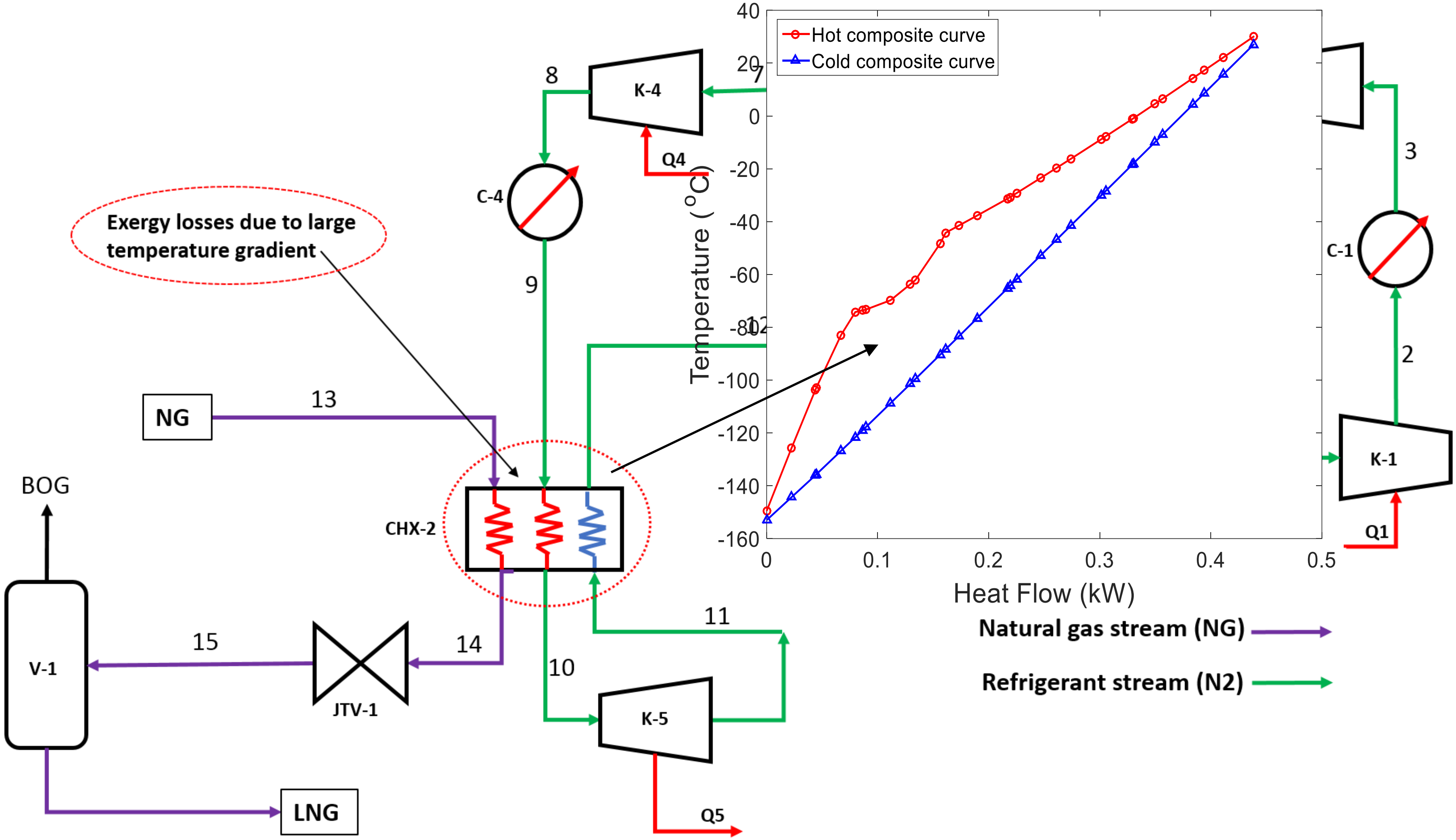
~40–50% [1] of the total LNG value

999) energy is required to liquefy

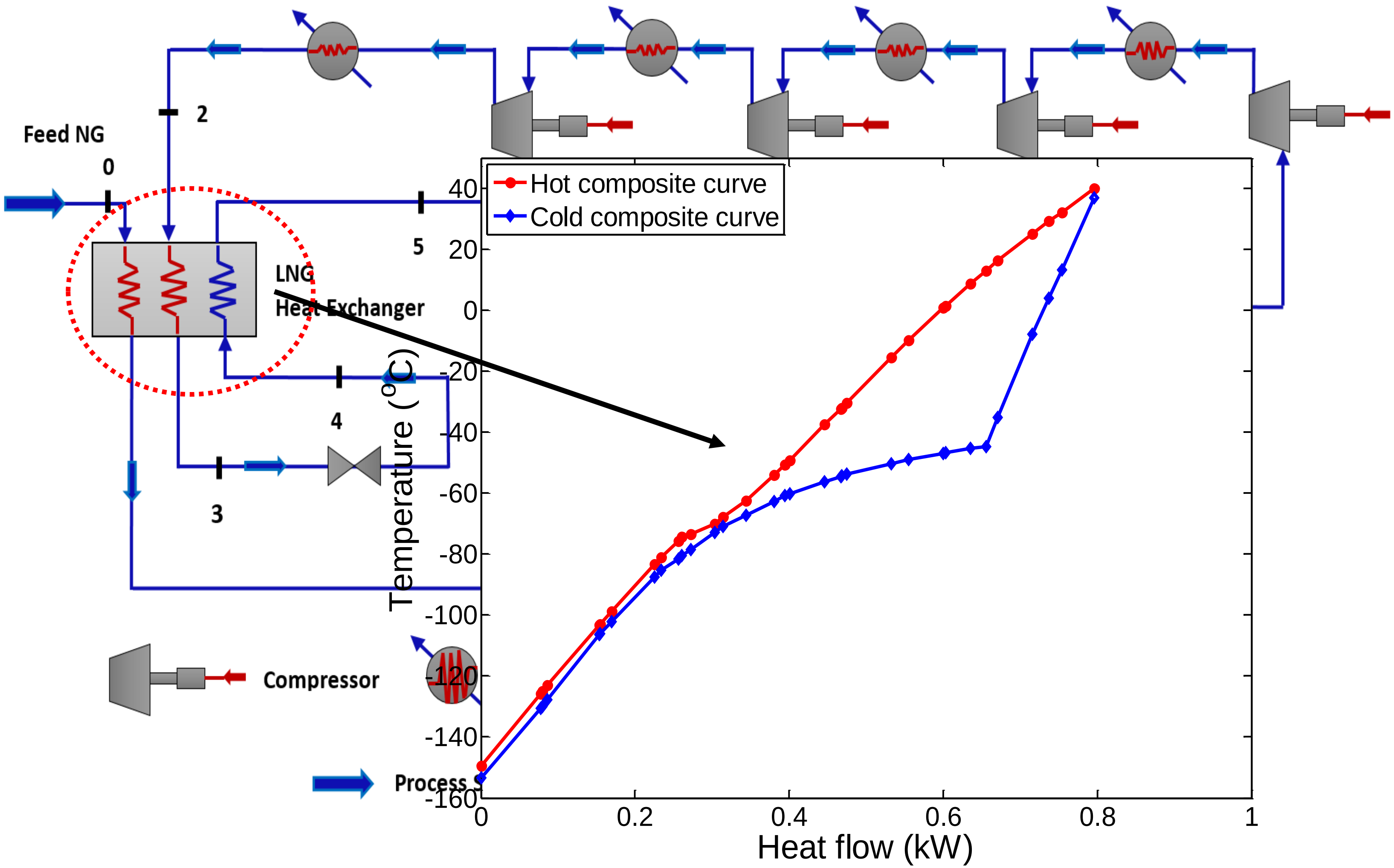
process and site conditions.

- N_2-expander process
- SMR process
- DMR process
- C3MR process
- Cascade process etc.

N_2-expander based LNG process



Single mixed refrigerant (SMR) process

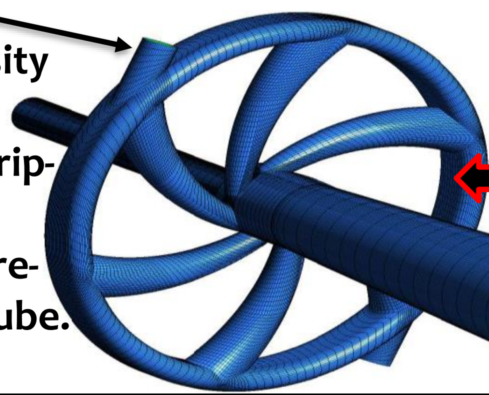


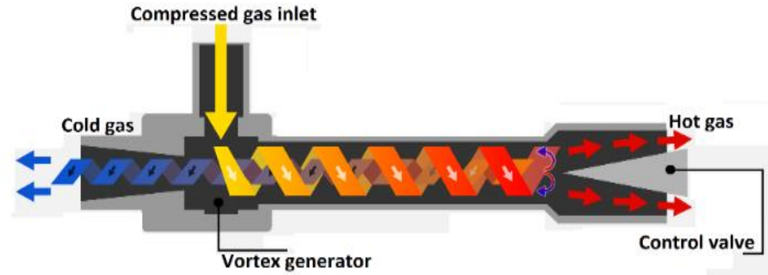
Vortex Tube- as an expansion device

- **Vortex tube is a simple device consists of no moving parts and was first described by Ranque (1933) and examined experimentally by Hilsch (1942) hence the name Ranque Hilsch.**
- **The main components of the vortex tube are nozzle, diaphragm, chamber, cylindrical tube, cone valve, hot air outlet, cold air outlet.**

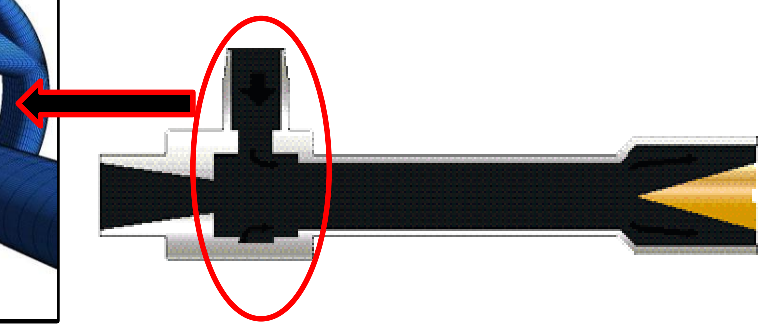
The main working principle depends Upon the pressure difference that causes the separa-tion of compressed gas. When compressed gas is injected tangentially in to the chamber through The Nozzle the swirls more like a tornado is Formed.

Because of lower density Of the hot gas it gets accumulated at the perip-heral of the inner tube while the cold gas is pre-sent in the middle of tube.

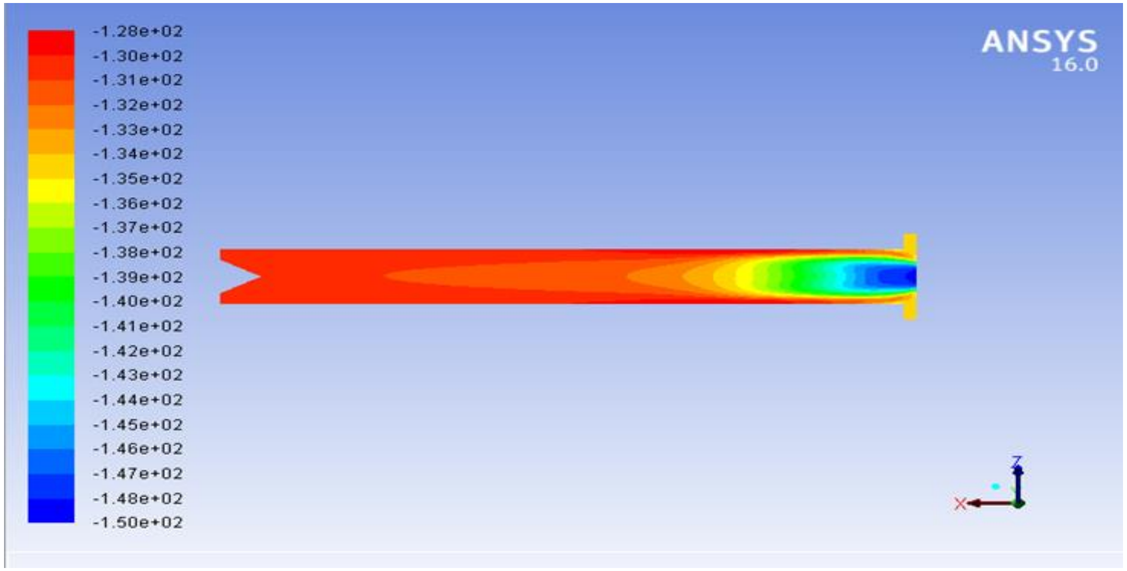




(courtesy of *AiRTX Vortex Tubes*)



CFD model of Vortex tube



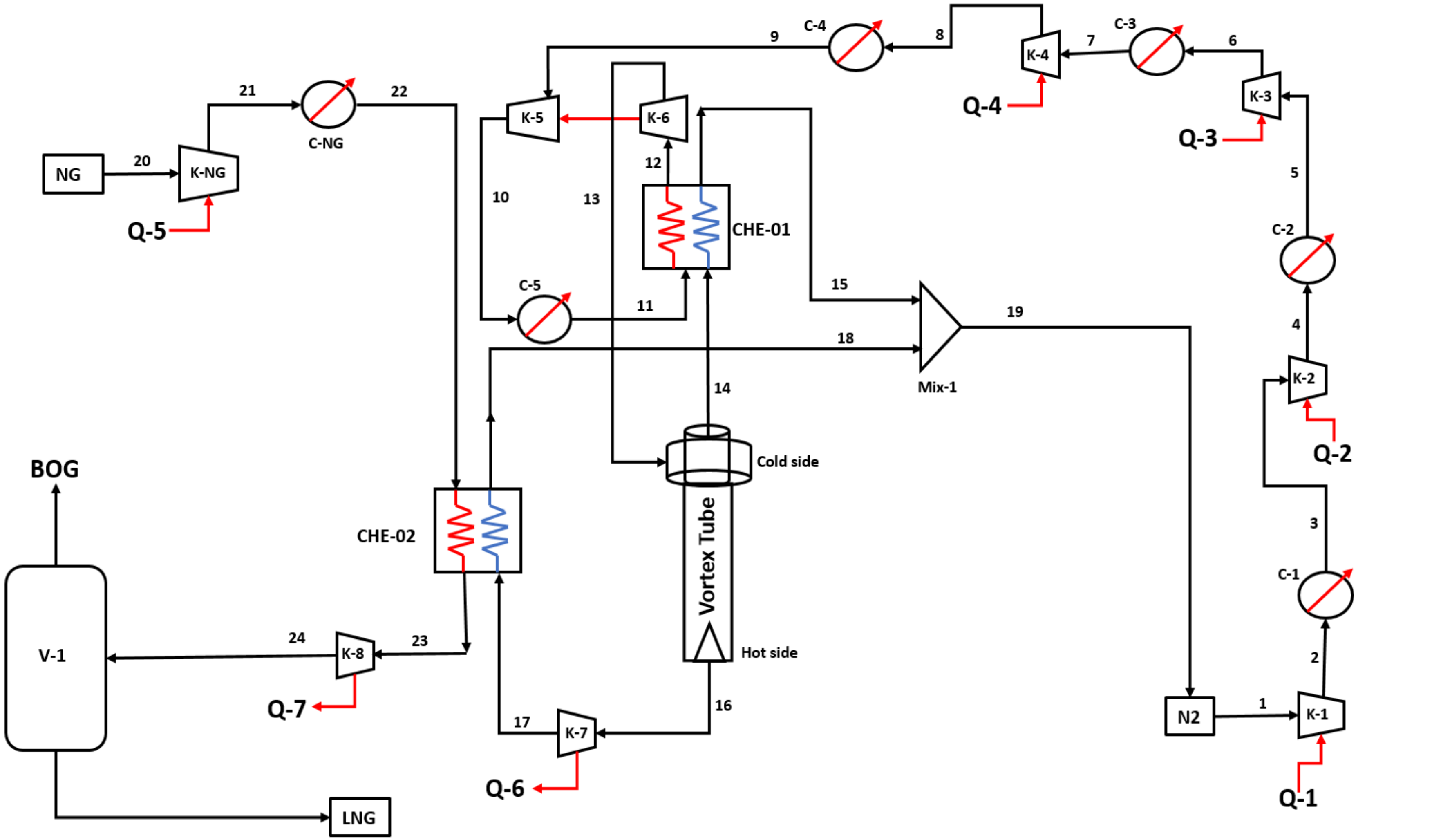
Geometrical parameters of the vortex tube

Measurement	Value
Working tube length (mm)	106
Working tube I.D. (mm)	11.4
Nozzle height (mm)	0.97
Nozzle width (mm)	1.41
Nozzle total inlet area (mm^2)	8.2
Cold exit diameter (mm)	6.2
Cold exit area (mm^2)	30.3
Hot exit diameter (mm)	11
Hot exit area (mm^2)	95

CFD results for working fluid Nitrogen.

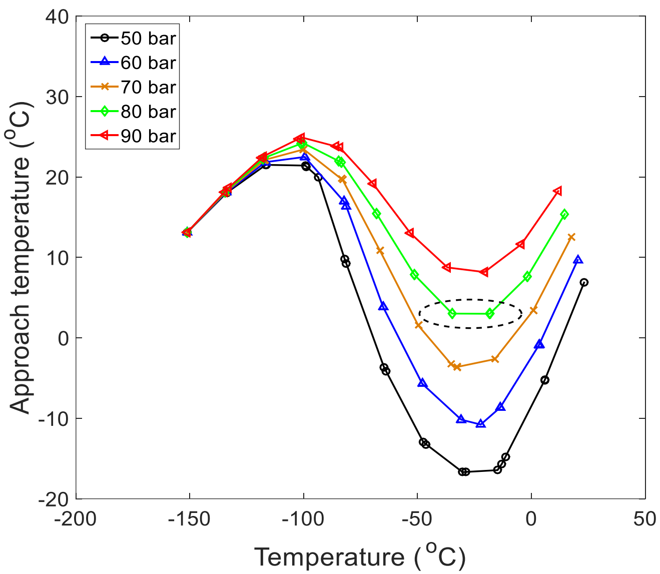
Property	Value
Inlet temperature (K)	139
Inlet Pressure (bar)	7
Cold side temperature (K)	123
Cold side Pressure (bar)	2
Cold mass fraction	0.25
Hot side temperature (K)	145
Hot side Pressure (bar)	3

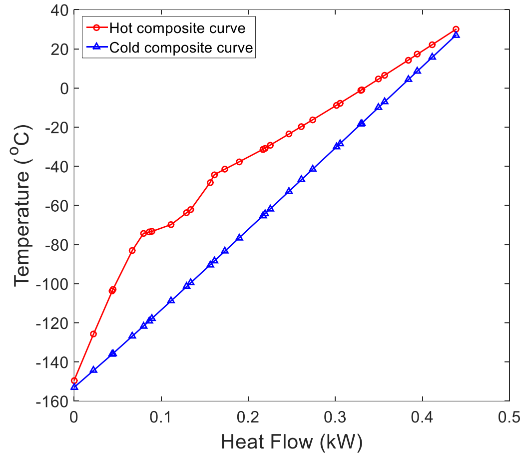
Vortex-Tube based LNG Process

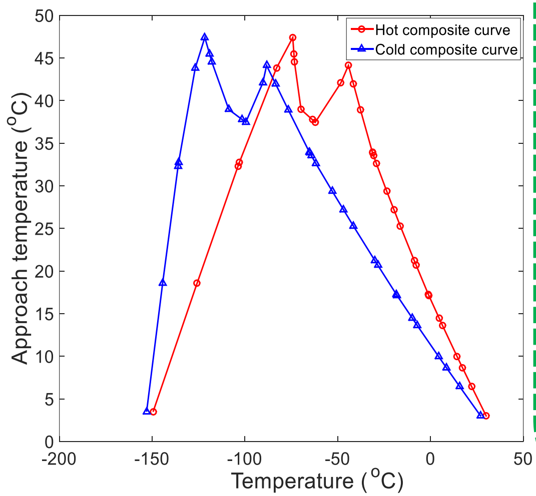


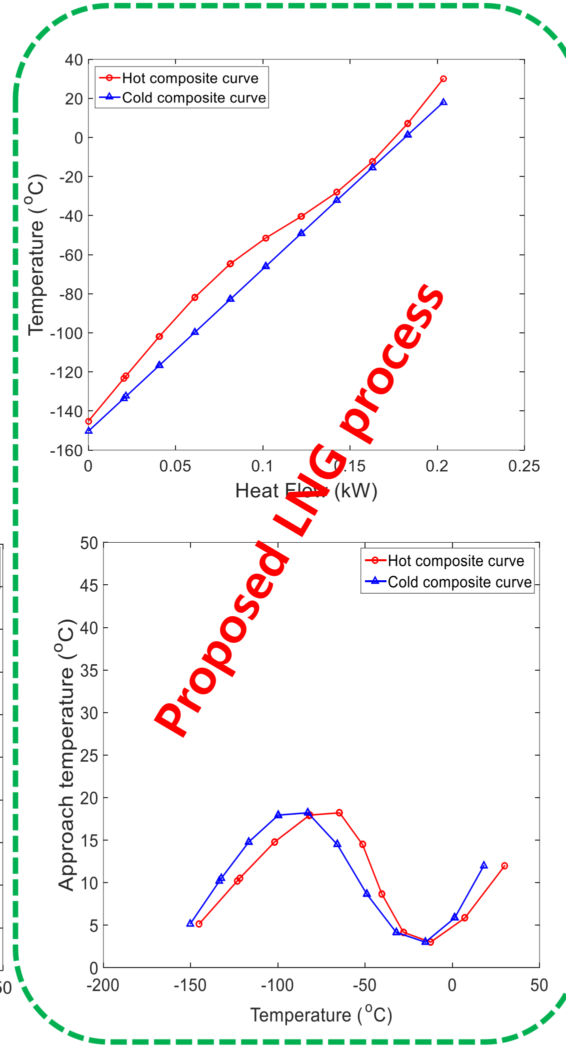
Research findings

Effect of feed NG boosting pressure on MITA values









N_2 expander LNG processes	Specific required energy
Du et al.	1.8717 kW/kg
Austbo and Gunderson	0.8114 kW/kg
Khan et al.	0.7449 kW/kg
Ding et al.	0.6200 kW/kg
Proposed LNG process	**0.5900 kW/kg**