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SELF STUDY MODULE

Liquefaction in everyday practice and its impacts

Objective

Liquefaction processes and their applications

Vocabulary

Simple Liquefaction Process: A single pass process to which a gas enters and a vapor and a liquid stream leaves.

Linde Process: A process to which a gas enters, and only a liquid leaves, the vapor is recycled and is mixed with the feed stream.

Throttling: Rapid decrease of pressure of a real fluid to cause sharp temperature decrease or liquefaction.

Useful diagrams

PH diagram of nitrogen

PH diagram of methane

PH diagram of CO2

Balance equations

The general mass conservation law $\frac{dm}{dt} = \sum_{in} m_i - \sum_{out} m_j$

The general conservation of energy or the first law of thermodynamics

$$\frac{dU}{dt} = \sum_{in} m_i h_i - \sum_{out} m_j h_j + \dot{Q} + \dot{W}_S - P\frac{dv}{dt}$$

The entropy balance has a generation term

$$\frac{dS}{dt} = \sum_{in} m_i s_i - \sum_{out} m_j s_j + \frac{\dot{Q}}{T} + \dot{S}_{gen}$$

Calculate

1. A group of COVID 19 vaccines require -80 C as storage medium. You are asked to design the system for this process. Dry ice seems a feasible domain. Find the PH diagram of CO2 and propose the flow chart for this system. How much energy is needed? How much cooling is required?
2. Design a liquefaction process for natural gas transportation. How much work is needed/kg and how much cooling is required/kg natural gas that is liquefied? Why do we liquefy natural gas?

Bibliography

S. Sandler Chemical Biochemical and Engineering thermodynamics, 4th edition, Wiley

M. Koretsky, Engineering and Chemical Thermodynamics, 2nd edition, Wiley, 2013, NY.

M.J. Moran, H. N. Shapiro, D.D. Boettner, M.B. Bailey, Principles of Engineering Thermodynamics, 7th edition, John Wiley and Sons, 2012, NY.