Possible approach to Extract helium 3 from Natural gas beside moon mining

Reading and References

Helium

Why We Are Running Out of Helium And What We Can Do About It
https://www.forbes.com/sites/quora/2016/01/01/why-we-are-running-out-of-helium-and-what-we-can-do-about-it/#450e961c57ad

Helium – Macro View Update
https://www.edisongroup.com/wp-content/uploads/2019/02/HeliumMacroUpdate2019.pdf

Helium: Qatar mulls Helium 4 plant possibilities
https://www.gasworld.com/helium-qatar-4-plant-considered/2014735.article

Helium Shortage 3.0
http://www.kornbluthheliumconsulting.com/wp-content/uploads/2019/08/Gasworld-Helium-Shortage-3.0-Update-August-2019-U.S.-Edition-FINAL.pdf

Helium in Natural Gas - Occurrence and Production
https://www.gasliquids.com/pdfs/2016_HeliumInNaturalGas.pdf

Purification of helium from natural gas by pressure swing adsorption
https://www.researchgate.net/publication/236882400_Purification_of_helium_from_natural_gas_by_pressure_swing_adsorption

Helium 3

Apparatus and method for separation of helium isotopes
https://patents.google.com/patent/US3421334A/en

Helium Isotopes Separated by Fluid-Plow
https://pubs.acs.org/doi/abs/10.1021/cen-v025n045.p3289

Helium 3
https://en.wikipedia.org/wiki/Helium-3

Possible Methods

Method 1 based on Apparatus and method for separation of helium isotopes Represents more energy needed and many inefficiencies

Helium-3 possesses normal viscosity below 2.173 K., but the superfluid component of helium-II (i.e., helium-4 below 2.173 K.) possesses zero viscosity, it is possible to separate helium-3 from helium- 4 'by a suitable filtration process. However, the fact that not all of the helium-4 transforms to the superfluid state (it is the superfluid which passes through the filter) in the presence of helium-3 necessitates additional means for separating the isotopes.

Method 2 **the chosen and created one**

Helium-3 boils at 3.19 K compared with helium-4 at 4.23 K, and its critical point is also lower at 3.35 K, compared with helium-4 at 5.2 K. Helium-3 has less than half the density of helium-4 when it is at its boiling point: 59 g/L compared to 125 g/L of helium-4 at a pressure of one atmosphere. Its latent heat of vaporization is also considerably lower at 0.026 kJ/mol compared with the 0.0829 kJ/mol of helium-4.
Price $2000 per liter H3 - $0.4 per liter of Helium - liquid helium costs about $5.00 per liter

Helium is also present as up to 7% of some natural gas sources, and large sources have over 0.5% (above 0.2% makes it viable to extract).

Physical constants:

- Atomic number 2
- Atomic mass 4.00260 g.mol $^{-1}$
- Electronegativity according to Pauling unknown
- Density 0.178*10 $^{-3}$ g.cm $^{-3}$ at 20 °C
- Melting point - 272.2 (26 atm) °C
- Boiling point - 268.9 °C
- Vanderwaals radius 0.118 nm
- Ionic radius unknown
- Isotopes 2
- Electronic shell 1s ^{2}
- Energy of first ionisation 2372 kJ.mol $^{-1}$

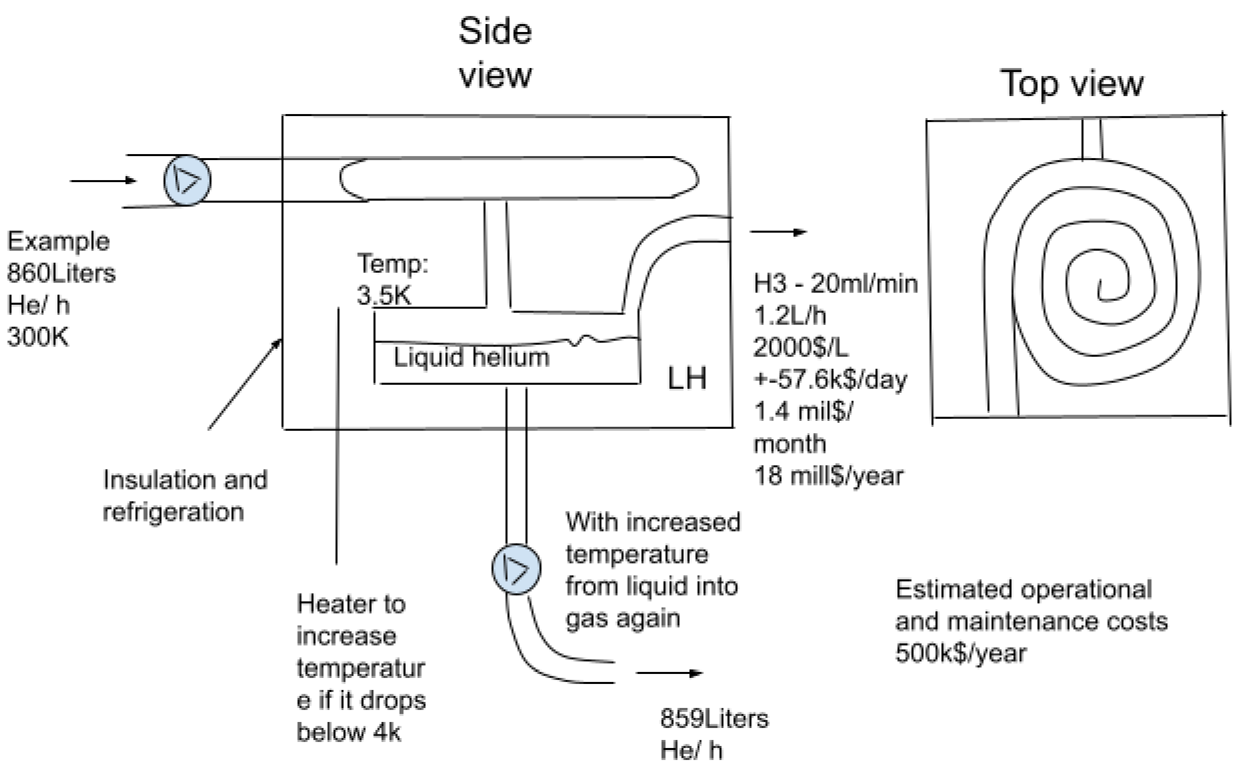
Helium-3 is a stable and lighter isotope of natural helium. It is an inert, nontoxic and nonflammable gas. It is colorless, tasteless and ordorless.
The fraction of ^{3}**He** in **helium** separated from natural gas in the U.S. was found to range from 70 to 242 parts per billion.(0.07 - 0.242 mg/kg or 0.00007-0.000242 g/Liter) Average plant can produce 860 liter helium per hour (2.6 ton per day)of helium

Physical constants:

- Atomic Number : 3
- Half-life : stable
- Number of Protons : 2
- Number of Neutron : 1
- The 3He nucleus contains a single neutron which gives a nuclear spin.
- Spin (Jp): 1/2+
- % Abundance = 0.0001373
- Molecular Weight : 3 016029.310 ± 0.001
- Boiling Point : -269.96°C (3.19°K)   Freezing point at 1 atm : none
- Critical point : -269.82°C (3.33°K)   Vapour pressure at 21.1°C (70°F) : N/A
- Density at 21.1°C (70°F) : 0.1650 kg/m3
- Mass excess (keV) : 14931.204 ± 0.001
- Binding energy (keV) : 7718.058 ± 0.002

Sketch of a possible simple system to capture H3 via temperature and flow control.

Need for an AI software to continuously optimize the pumps and temperature and predict anomalies - failures etc...



Length and diameter of the tubing

- Temperature of liquid helium is a considered constant @3.5k inside the system.
- Helium gas(Cp = 5.2 kJ/kg K(j/g K); μ = 15 x 10^{-6} Pa s; ρ = 0.3 kg/m3, k = 0.1W/mK)
- Helium flow of 860L/h=125g/h=0.0347g/s=m
- Assumed pressure drop=ΔP = 10-15 Kpa??
- Temperature between 300k and 3.5K
- Tx=0= 300k ; Tx=L = 4K ; TLiquid helium tank = 3.5k
- Q = mCp (Tin −Tout) =0.0347g/s x 5.2 J/g K x 296.5K = 53.5 W
- Log mean ΔT: ΔTlm = ΔTf(x=0) - ΔTf(x=L) / ln(ΔTf(x=0)/ ΔTf(x=L))
- ΔTlm = (300-3.5) - (4-3.5) / ln[(300-3.5)/ (4-3.5)] = 52Kelvin
- UA=hπDL = Q/ ΔTlm = 53.5 W/52 K = 1.03 W/K
- The heat transfer coefficient is a function of Re_D and Pr = 0.67
- Assuming the flow is turbulent and fully developed,
- Use the Dittus Boelter correlation: Nu_D = hD/Kf =0.023.$Re_D^{0.8}Pr^{0.3}$
- And : Re_D=4m / πDμ
- Substituting the Re_D and solving for h
- h=0.023Kf/D(4m / πDμ)$^{0.8}$Pr$^{0.3}$
- h= 0.0247 x 0.1W/mK x (0.0000347kg/s)$^{0.8}$/ (15 x 10^{-6} Pa s)$^{0.8}$ x $D^{1.8}$
- h=0.002429/$D^{1.8}$
- hπDL = 0.00077357 x (L/$D^{0.8}$)=1.03 W/K => L/$D^{0.8}$ = 1331.5m
- ΔP = f x L/2ρD x (m/A_{flow})^2 ; A_{flow}=$\pi D^2/4$ and f=0.02(guess)
- Re_D=4m / πDμ = 4x 0.0000347kg/s / 3.14 x m x 15 x 10^{-6} Pa s =
- Substituting for Re_D and f
- ΔP = 0.016 x m^2/ ρ x L/D^5= (0.016 x0.0000347kg/s)/ 0.3Kg/m3 x (L/D^5)
- ΔP = 1.85 x 10-6 x (L/D^5)
- Substitute: L= 1331.5m*$D^{0.8}$=> ΔP = 1.85 x 10-6 x ($D^{4.2}$)
- If ΔP= 10000 pa
- D= [0.002463275/10000]$^{1/4.2}$=0.026m= 26mm
- L= 1331.5m*$D^{0.8}$= 71.8meters