Quiz 7
Chemical Engineering Thermodynamics
February 23, 2017

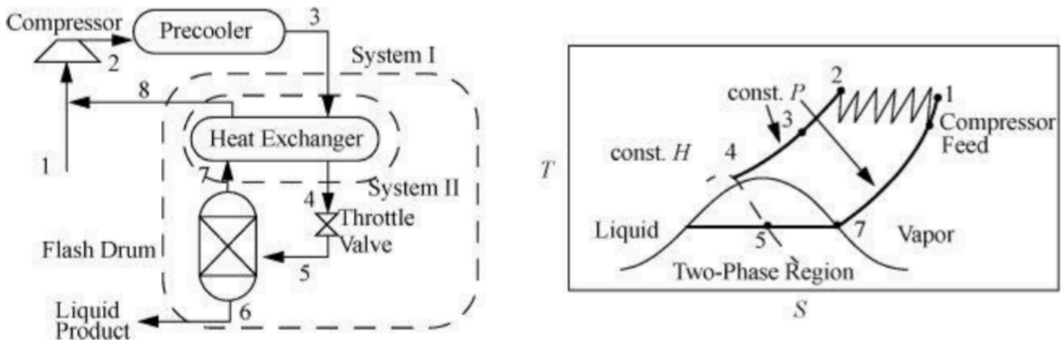


Figure 5.12. Linde liquefaction process schematic. The system boundaries shown on the left

a) Figure 5.12 shows the Linde liquefaction process. Sketch a P/H diagram showing the eight streams of the Linde process. (show 2 and 2')

b) Make a table for each stream indicating the state (sat. vap. etc.), T, P, H, S, η_θ, q, dm/dt (mass flow rate). Assuming that you have the P/H diagram and that you are given the pressure and temperature for streams 3 and 8. Which streams can be immediately solved for H and how. Fill in as much as you can from the initial information including indicating which streams have the same flow rate, P, T, H, S and how you would use η_θ.

c) Can streams 1 and 2 be initially ignored? Why?

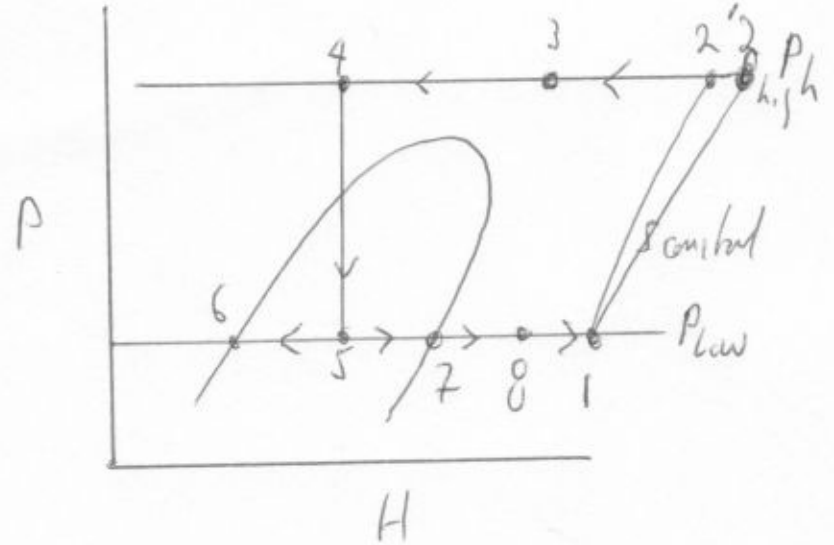
d) The two dashed lines in Figure 5.12 indicate two local balances that need to be considered to solve this design. Show how the System I balance in mass and in energy can yield q for stream 5.

e) Show how q can yield H_5.

f) Show how H for stream 4 can be resolved from an energy balance on system II.

Answers Quiz 7
ChE Thermo
2/23/17

a)



b)

	State	T	P	H	S	η_θ	$\dot m$
1	SHS		P_8	H_1	~~$\dot m_1 S$~~ S_1	—	$\dot m_2 - \dot m_8$
2'	↓		P_3	H_2'	$\frac{\dot m_1 S_1 + \dot m_8 S_8}{\dot m_2}$	—	$\dot m_3$
2			P_3	$\left(\left(\frac{\dot m_1 H_1 + \dot m_8 H_8}{\dot m_2}\right) + H_2'\right)/\eta_\theta + \left(\frac{\dot m_1 H_1 + \dot m_8 H_8}{\dot m_2}\right)$		η_θ	$\dot m_3$
3		T_3	P_3	H_3	S_3	—	$\dot m_3$
4			P_3	↓		—	$\dot m_3$
5	V/L	T_6	P_8	H_4		—	$\dot m_3$
6	SL	T_6	P_8	H_6	S_6	—	$\dot m_6$
7	SV	T_6	P_8	H_7	S_7	—	$\dot m_8$
8	SHS	T_8	P_8	H_8	S_8	—	$\dot m_8$

- Streams 3 & 8 can be solved from the P/H chart
- Streams 6, & 7 can be solved immediately since they are at P_8 & SV or SL

c) Streams 1 & 2 can be ignored since they only provide T & P for stream 3.

d)

$$\dot{m}_3 = \dot{m}_6 + \dot{m}_8 \qquad \dot{m}_6 = \dot{m}_3 - \dot{m}_8 \quad (1)$$

$$H_3 \dot{m}_3 = H_6 \dot{m}_6 + H_8 \dot{m}_8 \quad (2)$$

$$q = \frac{\dot{m}_8}{\dot{m}_3}$$

using (1) in (2)

$$H_3 \dot{m}_3 = H_6 (\dot{m}_3 - \dot{m}_8) + H_8 \dot{m}_8$$

$$H_3 = H_6 \left(1 - \frac{\dot{m}_8}{\dot{m}_3}\right) + H_8 \left(\frac{\dot{m}_8}{\dot{m}_3}\right)$$

$$(H_3 - H_6) = \frac{\dot{m}_8}{\dot{m}_3} (H_8 - H_6)$$

$$q = \frac{\dot{m}_8}{\dot{m}_3} = \frac{(H_3 - H_6)}{(H_8 - H_6)}$$

e) $$H_5 = H^{L}_{P_8} + q\left(H^{V}_{P_8} - H^{L}_{P_8}\right)$$

f) $$H_4 \dot{m}_3 - H_3 \dot{m}_3 = H_8 \dot{m}_8 - H_7 \dot{m}_8$$

$$\frac{\dot{m}_8}{\dot{m}_3} = q \quad \therefore \quad H_4 = q(H_8 - H_7) + H_3$$