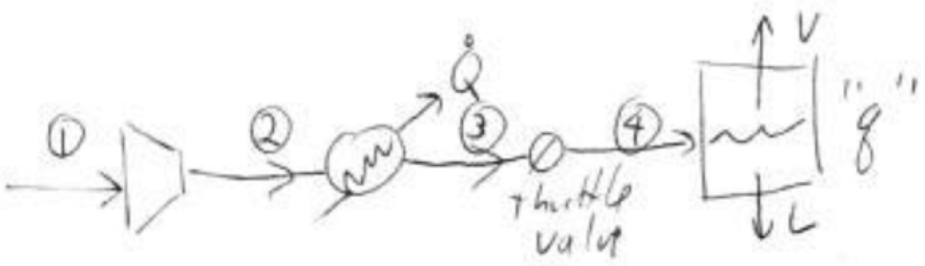
**Quiz 6**
**Chemical Engineering Thermodynamics**
**February 16, 2017**

Homework 4.30 involved a two-stage compressor with inter-stage cooling to produce liquid propane. The result of that analysis was $W_I$ = 150 kJ/kg, $W_{II}$ = 250 kJ/kg, $Q_I$ = 160 kJ/kg, and $Q_{II}$ = 560 kJ/kg with the final product having q = 0.48 (51% liquid). It was stated in class that a multistage compressor is more efficient compared to a single stage compressor. Redo this calculation for a single stage compressor using the following table for input parameters




| | State | T, °F | P, Mpa | ηθ | q | H, kJ/kg | S, Btu/lb-F° |
|---|---|---|---|---|---|---|---|
| 1 | V | 80 | 0.1 | | - | | |
| 2' | V | | 4.5 | | - | | |
| 2 | V | | 4.5 | 0.80 | - | | |
| 3 | V | 116 | | | - | | |
| 4 | V/L | | 0.1 | | | | |

-Obtain the work for the compressor and compare it with the sum of the work for the two compressors given above.
-Obtain the cooling, Q, and compare it with the sum of the Q's from the two stage compressor.
-Finally, obtain the fraction liquefied in the last stage and compare it with the fraction obtained from the two stage compressor.
-Is the dual stage compression more efficient? What is the downside to dual stage compression?

# Quiz 6

| | State | T, °F | P, MPa | $\eta_0$ | q | H, kJ/kg | S, Btu/lb-°R |
|---|---|---|---|---|---|---|---|
| 1 | V | 80 | 0.1 | | – | 980 | 1.47 |
| 2' | V | 350 | 4.5 | | – | 1200 | 1.47 |
| 2 | V | 390 | 4.5 | 0.8 | – | 1260 | 1.50 |
| 3 | V | 116 | 4.5 | 0 | – | 640 | 1.12 |
| 4 | L/V | 80 | 0.1 | | 0.48 | 640 | 1.15 |

$W_I' = 1260 \frac{kJ}{kg} - 980 \frac{kJ}{kg} = 220 \frac{kJ}{kg}$

$W_I = \frac{220 kJ/kg}{0.8} = 275 \frac{kJ}{kg}$

$H_2 = 980 + 275 = 1260 \; kJ/kg$

$Q_I = 1260 \frac{kJ}{kg} - 640 \frac{kJ}{kg} = 620 \frac{kJ}{kg}$

$H^V_{0.1 MPa} = 850 \frac{kJ}{kg}$

$H^L_{0.1 MPa} = 430 \frac{kJ}{kg}$

$640 \frac{kJ}{kg} = 430 \frac{kJ}{kg} + q(850 \frac{kJ}{kg} - 430 \frac{kJ}{kg})$

$\frac{640 \frac{kJ}{kg} - 430 \frac{kJ}{kg}}{420 \frac{kJ}{kg}} = q$

$q = 0.48$

q is the ratio between dual & six stage Compressions

52°C Liquid

$\Sigma W$ is $400 \frac{kJ}{kg}$ for 2 stage & $275 \frac{kJ}{kg}$ for six stage

$\Sigma Q$ is $720 \frac{kJ}{kg}$ for 2 stage & $620 \frac{kJ}{kg}$ for six stage

# E.11 PRESSURE-ENTHALPY DIAGRAM FOR PROPANE

(Source: NIST, Thermophysics Division, Boulder, CO, USA, used with permission.