Appendix A: Sample Calculation

Steps from Data Analysis:

2. Average two sets of data: $N_{ave} = \frac{N_1 + N_2}{2}$, where N = variable (e.g., Load, RPM, etc...)

Pick Case 1, Load = 20%, RPM = 1800

3. $P_2 = 33.8 \text{ psig} \Rightarrow 33.8 + 14.7 = 48.5 \text{ psia}$

$T_2 = 279\,°F$

Table A-4E ⇒ saturated, assume saturated vapor

$h_2 = h_g \text{ at } T_2 = 1173.8 \text{ Btu/lbm}$

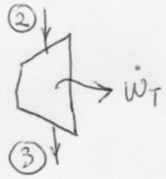
$S_2 = S_g \text{ at } T_2 = 1.66 \text{ Btu/lbm R}$

4. $\vec{T} = 7.2 \text{ ft-lb}$, RPM = 1800

$$\dot{W}_T = \frac{\vec{T} * RPM}{5252} = \frac{(7.2)(1800)}{5252} = \boxed{2.47 \text{ Hp}}$$

$$2.47 \text{ Hp} * 745.7 \frac{W}{HP} = \boxed{1842 \text{ W}}$$

$$2.47 \text{ Hp} * 2544 \frac{\text{Btu}/\text{hr}}{HP} = \boxed{6279 \text{ Btu/hr}}$$

5. 

COE: $0 = \text{out} - \text{in} + \cancel{\text{storage}}$ steady flow

$0 = \dot{W}_T + \dot{m} h_3 - \dot{m} h_2$

$\boxed{\dot{m} \text{ and } h_3 \text{ are unknown so far}}$

6. Properties of subcooled liquids ≈ props. of saturated liquid at T. This approximation is valid because T influences state much more than P.

$$T_7 = 210\,°F \Rightarrow h_7 \approx h_f \text{ at } 210\,°F = \boxed{178.14 \text{ Btu/lbm}}$$

7. $T_4 = 78\,°F$ & subcooled $h_4 \approx h_f \text{ at } 78\,°F = \boxed{46.09 \text{ Btu/lbm}}$

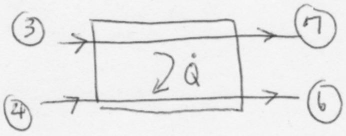
$T_6 = 88\,°F$ & subcooled $h_6 \approx h_f \text{ at } 88\,°F = \boxed{56.07 \text{ Btu/lbm}}$

Ave. density $= \frac{1}{v_{ave}}$ $v_{ave}(83\,°F) \approx 0.016 \frac{ft^3}{lbm}$ $\rho_{ave} = \frac{1}{0.016} = \boxed{62.5 \frac{lbm}{ft^3}}$

Flow $= 92.8 \frac{gal}{min} * \frac{60\,min}{hr} * .13368 \frac{ft^3}{gal} = 7443 \frac{ft^3}{hr}$ $\dot{m}_w = \rho \text{ Flow} = \boxed{465206 \frac{lbm}{hr}}$

Appendix A (cont.)

8.



COE from ④ to ⑥ : $0 = \dot{m}_w h_6 - \dot{m} h_4 - \dot{Q}$

$\dot{Q} = \dot{m}_w (h_6 - h_4) = 46520.6 (56.07 - 46.09)$

$= 4642760 \ \frac{Btu}{hr} = 4.643 \times 10^5 \ \frac{Btu}{hr}$

COE from ③ to ⑦ : $0 = \dot{Q} + \dot{m}(h_7 - h_3)$

$\boxed{\dot{m} \text{ and } h_3 \text{ are unknown}}$

9) COE from ③ to ⑦ : $\dot{m} = \frac{\dot{Q}}{h_3 - h_7}$

Plug in turbine COE: $0 = \dot{W}_T + \frac{\dot{Q}}{(h_3 - h_7)}(h_3 - h_2)$

$0 = 6279 + 4.643 \times 10^5 \frac{(h_3 - 1173.8)}{(h_3 - 178.14)}$

Solve : $\boxed{h_3 = 1160.7 \ Btu/lbm}$ $\boxed{\dot{m} = 472.5 \ \frac{lbm}{hr}}$

10. $P_3 = 0.1$ psig $= 14.8$ psia

$h_3 > h_g$ at 14.8 psia $\Rightarrow$ $\boxed{\text{Superheated}}$

11. $\dot{W}_{T,S} = \dot{m}(h_2 - h_{3S})$ h_{3S} defined by $P_3 = 14.8$ psia, $S_3 = S_2 = 1.66$ Btu/lbmR

$S_f < S_{3S} < S_g \Rightarrow$ saturated mixture

$x_{3S} = \frac{S_{3S} - S_f}{S_{fg}}$ at 14.8 psia $= \frac{1.66 - .312}{1.445} = 0.93$

$h_{3S} = h_f + x_{3S} h_{fg}$ at 14.8 psia $= 180.15 + (.93)(970.4) = 1085.4$

$\dot{W}_{T,S} = (472.5)(1173.8 - 1085.4) = 43123$ Btu/hr

12. $\eta_T = \frac{\dot{W}_T}{\dot{W}_{T,S}} = \frac{6279}{43123} = \boxed{0.15}$