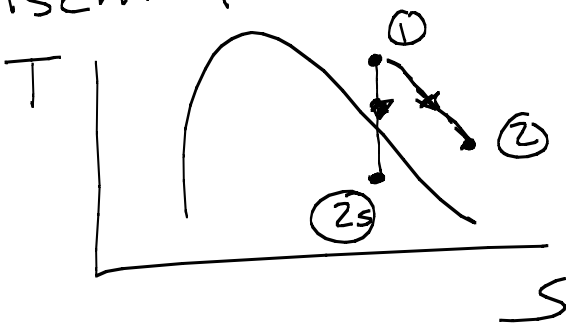
Problem 6

Given: - Steam in an insulated turbine at steady state

- $p_1 = 140\ lb/in^2$, $T_1 = 1000°F$
- $\dot{m} = 3.24\ lb/s$
- $p_2 = 2\ lb/in^2$

Determine: (a) Max theoretical power

(b) If $T_2 = 200°F$, the isentropic efficiency



(a) Max Power => Isentropic $s_{2s} = s_1$

Table A-4E @ $p = 140\ lb/in^2$, $T = 1000°F$

$s_1 = 1.8827\ Btu/lb·°R = s_{2s}$

$h_1 = 1531\ Btu/lb$

Table A-3E @ $p = 2\ lb/in^2$ $s_f = 0.1750\ Btu/lb°R$ $s_g = 1.9198\ Btu/lb°R$

$h_f = 94.02\ Btu/lb$, $h_{fg} = 1022.1\ Btu/lb$

$$x_{2s} = \frac{1.8827 - 0.1750}{1.9198 - 0.1750} = 0.9787$$

$$h_{2s} = 94.02 + 0.9787\,(1022.1\ \text{Btu/lb})$$

$$h_{2s} = 1094.35\ \text{Btu/lb}$$

$$\dot{W}_{cv} = \dot{m}\,(h_1 - h_{2s})$$

$$= (3.24\ \text{lb/s})(1531\ \text{Btu/lb} - 1094.35\ \text{Btu/lb})$$

$$\boxed{\dot{W}_{cv} = 1414.75\ \text{Btu/s} = 2001\ \text{hp}}$$

(b) $$\eta_t = \frac{h_1 - h_2}{h_1 - h_{2s}}$$

Table A-4E @ $P = 2\ \text{lb/in}^2$, $T = 200^\circ\text{F}$

$\Rightarrow h_2 = 1149.7\ \text{Btu/lb}$

$$\eta_t = \frac{(1531 - 1149.7)\ \text{Btu/lb}}{(1531 - 1094.35)\ \text{Btu/lb}} = 0.873$$

$$\eta_t = 87.3\%$$