39.22 A refrigeration cycle using R-22 operates between $0°F$ and $80°F$ with a refrigerant flow rate of $300\frac{lb_m}{hr}$. There is no superheat and no subcooling. What is the refrigeration effect?

A. $1.8tons$

B. $2.0tons$

C. $2.2tons$

D. $2.4tons$

In the Reference Handbook look up Pressure Versus Enthalpy Curves for Refrigerant 22 and work around the cycle recording the enthalpy at each state in the refrigeration cycle. The refrigeration effect is the heat absorbed by the evaporator during the process $4 \rightarrow 1$, therefore we are interested in h_1 and h_4.

State 1, Since there is no superheat, locate State 1 on the right side of the saturation curve.

$$T_1 = 0°F$$

$$\chi_1 = 1$$

$$h_1 = 104.6\frac{Btu}{lb}$$

State 2, Assume isentropic compression to state 2. To save time, approximate the location of State 2 and move on as the enthalpy for state 2 is not required to find the refrigeration effect.

State 3, Since there is no subcooling, locate state 3 on the left side of the saturation curve.

$$T_3 = 80°F$$

$$\chi_3 = 0$$

$$h_3 = 33.3\frac{Btu}{lb}$$

State 4, Assume isenthalpic expansion from State $3 \rightarrow 4$, therefore:

$$h_4 = h_3 = 33.3\frac{Btu}{lb}$$

The mass flow rate is given, and h_1 and h_4 have been determined. Calculate the refrigeration effect:

$$Q_L = \dot{m}\left(h_1 - h_4\right) = \left(300\frac{lb}{hr}\right)\left(104.6\frac{Btu}{lb} - 33.3\frac{Btu}{lb}\right) = 21,390\frac{Btu}{hr}\left(\frac{1ton}{12,000\frac{Btu}{hr}}\right) = 1.8tons$$

Answer A

39.23 $500\frac{lb_m}{hr}$ **of superheated steam at** $900°F$ **and** $500psia$ **enters a turbine and expands to atmospheric pressure. The turbine is 70% efficient and powers a 90% efficient generator. What is the output power?**

A. $29KW$

B. $33KW$

C. $36KW$

D. $52KW$

The energy delivered by the turbine generator is a function of the enthalpy given up by the steam during expansion in the turbine, the turbine efficiency, and the generator efficiency. To start, bring up the steam table in the reference handbook by searching for Properties of Superheated Steam and Properties of Saturated Water (Pressure) and determine the enthalpy entering and leaving the turbine. Call the entering condition State 1 and the leaving condition State 2.

State 1, The superheated steam is fully defined since the temperature and pressure are known. In addition to the enthalpy, note the entropy for State 1.

$$T_1 = 900°F$$

$$P_1 = 500psia$$

$$h_1 = 1466.9\frac{Btu}{lb}$$

$$s_1 = 1.699\frac{Btu}{lb°F}$$

State 2, Start by assuming isentropic (ideal) expansion in the turbine. Use the entropy to determine the quality, and use the quality to determine the enthalpy for State 2 *ideal*. In the subsequent step we will distinguish State 2 *actual*.

$$P_2 = 14.7psia$$

$$s_2 = s_1 = 1.699\frac{Btu}{lb°F}$$

$$s_f = 0.3122\frac{Btu}{lb°F} \;\; ; \;\; s_{fg} = 1.4443\frac{Btu}{lb°F}$$

$$\chi_2 = \frac{s_2 - s_f}{s_{fg}} = \frac{1.699\frac{Btu}{lb°F} - 0.3122\frac{Btu}{lb°F}}{1.4443\frac{Btu}{lb°F}} = 0.96$$

$$h_f = 180.2\frac{Btu}{lb} \;\; ; \;\; h_{fg} = 970.1\frac{Btu}{lb}$$