Solve problem in 2 steps:  
- First, determine what $Q_L$ must be to maintain ice production. Use first law for open c.v.  
- Use Carnot refrigerator to determine minimum power input required to maintain that rate of heat rejection.
1st Problem

Process Description: 555°F freezing of water

\[ T = 500°F \quad T_0 = 25°F \]

Analysis Plan

State model: incompressible, substance

Laws: 1st law 555°F process

\[ Q + m_i (h_a + g \cdot z_i) = W + m_i (h + g \cdot z_e) \]

Assumptions

1) Pressure atmospheric
2) OPE, oku no
3) Ice sat, water sat

Implications

Freeze flat \( c \), reflect \( 1 \)st law

Easy boiler up

1st Law 16

\[ Q = m_c (h_a + h_i) \quad \text{sat solid water @ 25°F} \]

\[ Q = m_c (h_a + h_i) \quad \text{sat liquid water @ 50°F} \]

\[ Q = 10 \frac{\text{Btu}}{\text{hr}} (-146.9 + 18.06) \frac{\text{Btu}}{\text{hr}} = -1640.9 \frac{\text{Btu}}{\text{hr}} \Rightarrow \dot{Q}_L = 1640.9 \frac{\text{Btu}}{\text{hr}} \]

2nd Problem

C.O.F.R. = \( \frac{\dot{Q}_L}{W_{in}} \Rightarrow W_{out} = \frac{\dot{Q}_L}{COP_R} \]

from thermal Trans C.T. \( \text{min} = \frac{T_0}{T_u - T_0} = \frac{485}{40} = 12.125 \)

\( W_{out, min} = \frac{\dot{Q}_L}{COP_{max}} = \frac{1640.9}{12.125} = 135.3 \frac{\text{Btu}}{\text{hr}} \)
2 a) P must be constant, because T is constant and phase is changing

b) 1st law for closed system w/ OPE OK ~ 0

\[ U_2 - U_1 = Q_2 - P \Delta V \]

\[ Q_2 = h_2 - h_1 \]

for constant P

\[ W_2 = P \Delta V \]

\[ \text{from A - II at 100 KPa (1 bar)} \]

\[ T = -26.43°C \]  
\[ h_1 = 215.06 \text{ kJ/kg} \]  
\[ S_1 = 0.9395 \text{ kJ/kg K} \]  
\[ S_2 = 0.0678 \]

since don't know mass, calc/unit mass

\[ q = h_2 - h_1 = h_g - h_f = h_f = 215.06 \text{ kJ/kg} \]

from 2nd law: \[ S_2 - S_1 > \frac{\Delta Q}{T} \]

\[ \Delta Q = T(s_2 - s_1) \]

\[ \Delta Q = (273.1 + 26.43)(0.9395 - 0.0678) \]

\[ = 215.06 \text{ kJ/kg} \]