

SOLUTION

NAME: _____

This is an open book quiz. You may use a four function calculator. An unsigned honors pledge will result in a zero.

1. Consider a Carnot power cycle where the working fluid is 0.5 lb of water. During the isothermal expansion, the water is heated at 600°F from a saturated liquid to a saturated vapor. The water then expands adiabatically until its temperature drops to 90°F and the quality is $x = 0.643$. The next process is the isothermal compression. Determine the quality at the end of this isothermal compression.

GIVEN: T_H, T_C, m, x_3

FIND: x_4

ASSUME: No KE or PE effects

ANALYSIS: $1 \rightarrow 2$ $\Delta E = Q - W \rightarrow \Delta U = Q - W \rightarrow Q_{12} = \Delta U + W_{12}$

$$Q_{12} = Q_H = m(u_2 - u_1) + m \int_1^2 p \, dv = m(u_2 - u_1) + m p (v_2 - v_1)$$

$$Q_H = m [u_2 + p_2 v_2 - (u_1 + p_1 v_1)] = m(h_2 - h_1) = Q_H$$

$$\eta_{rev} = 1 - \frac{T_C}{T_H} = 1 - \frac{549.7^\circ R}{1059.7^\circ R} = 0.4813 = \eta$$

$$\eta = 1 - |Q_C/Q_H| \rightarrow \eta - 1 = -|Q_C/Q_H| \rightarrow 1 - \eta = |Q_C/Q_H| \rightarrow Q_C = Q_H(1 - \eta)$$

$3 \rightarrow 4$ $\Delta E = Q - W$ $\Delta U = Q - W$ $Q = \Delta U + W$ $Q_{34} = m(u_4 - u_3) + m \int_3^4 p \, dv = m(u_4 - u_3) + m p (v_4 - v_3)$

$$Q_{34} = m [u_4 - u_3 + p_4 v_4 - p_3 v_3] = m(h_4 - h_3)$$

$$Q_{34} = Q_C = m(h_4 - h_3) \rightarrow Q_C/m = h_4 - h_3 \quad h_4 = h_3 + Q_C/m$$

Combining $h_4 = h_3 + \frac{Q_H(1 - \eta)}{m} = h_3 + \frac{\eta(h_2 - h_1)(1 - \eta)}{\eta}$

$$h_4 = h_3 + (h_2 - h_1)(1 - \eta)$$

Go to tables $h_1 = h_f(600^\circ F) = 616.7 \text{ Btu/lb}$ $h_2 = h_g(600^\circ F) = 1166.4 \text{ Btu/lb}$

At 90°F $h_f = 58.07 \text{ Btu/lb}$ $h_g = 1100.7 \text{ Btu/lb}$ $h_3 = (1 - x_3)h_f + x_3 h_g$

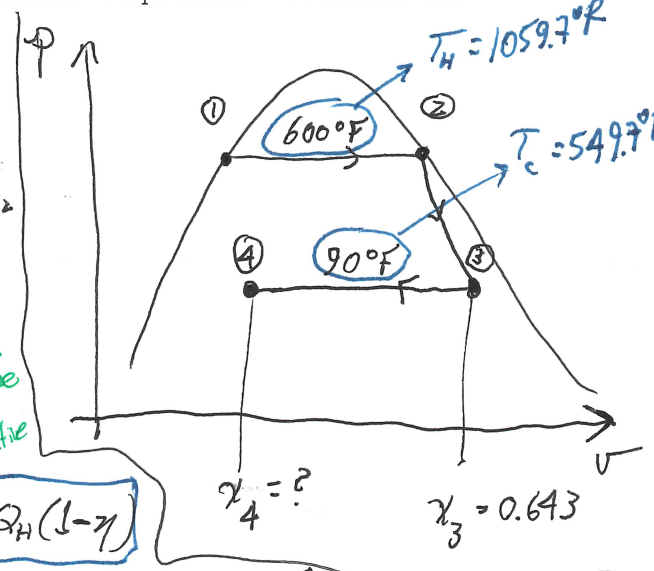
$$h_3 = 728.48 \text{ Btu/lb}$$

$$h_4 = 728.48 \text{ Btu/lb} + (1166.4 \text{ Btu/lb} - 616.7 \text{ Btu/lb})(1 - 0.4813)$$

$$h_4 = 443.35 \text{ Btu/lb} = (1 - x_4)(58.07 \text{ Btu/lb}) + x_4(1100.7 \text{ Btu/lb})$$

$$x_4 = 0.369 \leftarrow \text{ANS.}$$

I HAVE NEITHER PROVIDED OR RECEIVED HELP DURING THIS QUIZ.



SIGNATURE _____