

$$\underline{10-18}$$

$$p_3 = 1500 \text{ psia} = p_2$$

$$p_1 = p_4 = 2 \text{ psia}$$

$$T_2 = 800^\circ \text{F}$$

$$n_T = 0.90$$

$$\dot{W}_{\text{net}} = 2500 \text{ kW}$$

$$h_1 = 94.02 \frac{\text{Btu}}{\text{lbm}}$$

$$v_1 = 0.01623 \text{ ft}^3/\text{lbm}$$

$$w_p = v(p_2 - p_1) = 0.01623(1500 - 2)$$

$$w_p = 4.50 \text{ Btu/lbm}$$

$$h_2 = h_1 + w_p = 94.02 + 4.50$$

$$h_2 = 98.52 \text{ Btu/lbm}$$

$$p = 1500 \text{ psia}$$

$$h_3 = 1363.1 \text{ Btu/lbm}$$

$$T = 800^\circ \text{F}$$

$$s_3 = 1.5064$$

$$p = 2 \text{ psia}$$

$$s_f = 0.175$$

$$s_{fg} = 1.7444$$

$$v_4 = \frac{1.5064 - 0.175}{1.7444} = 0.763$$

$$h_4 = 94.02 + 0.763(1021.7)$$

$$h_4 = 873.9 \text{ Btu/lbm}$$

$$n_r = \frac{h_3 - h_4}{h_3 - h_4}$$

$$h_4 = h_3 - n_r(h_3 - h_4)$$

$$h_4 = 1363.1 - 0.9(1363.1 - 873.9)$$

$$h_4 = 922.8 \text{ Btu/lbm}$$

$$q_{in} = h_3 - h_2$$

$$q_{in} = 1363.1 - 98.5 = 1264.6 \text{ Btu/lbm}$$

$$q_{out} = h_4 - h_1$$

$$q_{out} = 922.8 - 94.02 = 828.8 \text{ Btu/lbm}$$

$$W_{\text{net}} = q_{in} - q_{out} = 1264.6 - 828.8$$

$$W_{\text{net}} = 435.8 \text{ Btu/lbm}$$

$$2500 \text{ kW} = 2364.5 \text{ Btu/s}$$

$$\dot{m} = \frac{\dot{W}_{\text{net}}}{W_{\text{net}}} = \frac{2364.5}{435.8} = \boxed{5.44 \text{ lbm/s}}$$

$$\dot{W}_r = \dot{m}(h_3 - h_4) = 5.44(1363.1 - 922.8)$$

$$\dot{W}_r = \boxed{2528.2 \text{ kW}}$$

$$\dot{Q}_{in} = \dot{m}(h_3 - h_2) = 5.44(1264.6) = \boxed{6876 \frac{\text{Btu}}{\text{s}}}$$

$$\eta = \frac{W_{\text{net}}}{Q_{in}} = \frac{2528}{6876} = \boxed{36\%}$$

10-25

prop from EES

$$h_1 = 273.01$$

$$V_1 = 0.001842$$

$$h_3 = 761.54$$

$$h_4 = 689.74$$

$$h_{us} = 670.40$$

$$\dot{m} = 305.6$$

$$\dot{m}_w = 555.9$$

$$c_p = 4.258$$

$$\eta = \frac{h_3 - h_4}{h_3 - h_{us}} = \frac{761.54 - 689.74}{761.54 - 670.40}$$

$$\eta = \frac{71.80}{91.14} = 0.788 = \boxed{78.8\%}$$

$$W_t = \dot{m}(h_3 - h_4) = 305.6(761.54 - 689.74)$$

$$W_t = 21943 \text{ kW}$$

$$W_p = v(p_2 - p_1) = 0.001842(3.23 \text{ MPa} - 0.41 \text{ MPa})$$

$$\eta_p = 0.9$$

$$W_p = \frac{W_p}{\eta_p} = 5.81 \frac{\text{kJ}}{\text{kg}}$$

$$W_p = 305.6(5.81) = 1776 \text{ kW}$$

$$W_{\text{net}} = W_t - W_p = 21943 - 1776$$

$$W_{\text{net}} = \boxed{20167 \text{ kW}}$$

$$Q_{\text{in}} = \dot{m} c_p (T_{\text{in}} - T_{\text{out}})$$

$$Q_{\text{in}} = 555.9(4.258)(160 - 40)$$

$$Q_{\text{in}} = 1651700 \text{ kW}$$

$$\eta = \frac{W_{\text{net}}}{Q_{\text{in}}} = \frac{20167}{1651700} = 0.122 = \boxed{12.2\%}$$

10-34

$$p_3 = 5000 \text{ kPa}$$

$$p_u = 1200 \text{ kPa}$$

$$p_g = 20 \text{ kPa}$$

$$x_u = x_g = 0.46$$

$$h_f = 251.1$$

$$h_{fg} = 2258.3$$

$$s_f = 0.832$$

$$s_{fg} = 7.076$$

$$h_g = h_f + x h_{fg}$$

$$h_g = 2115.1$$

$$s_g = s_f + x s_{fg} = 0.832 + 0.46(7.076)$$

$$s_g = 7.63$$

$$s_s = s_g$$

$$s = 7.63$$

$$T_s = 481^\circ\text{C}$$

$$h_s = 3460 \frac{\text{kJ}}{\text{kg}}$$

$$h_f = 798.9$$

$$h_{fg} = 1984$$

$$h_u = 798.9 + 0.46(1984)$$

$$h_u = 2703.1$$

$$s_u = s_f + x s_{fg} = 2.12 + 0.46(4.41)$$

$$s_u = 6.41$$

$$s_g = s_u$$

$$s = 6.41$$

$$T_g = 327^\circ\text{C}$$

$$h_g = 3090$$

$$V_f = 0.001$$

$$\Delta p = 5000 - 20 = 4980 \text{ kPa}$$

$$w_p = V \Delta p$$

$$w_p = 0.001(4980) = 4.98 \frac{\text{kJ}}{\text{kg}}$$

$$w_{t_2} = h_s - h_g = 3460 - 2515 = 945$$

$$w_t = 1332$$

$$q_B = h_3 - h_2$$

$$h_1 = 251 \quad h_2 = 256$$

$$q_B = 3090 - 256 = 2834$$

$$q_R = h_5 - h_4 = 3460 - 2703 = 757$$

$$q_{in} = 3541$$

$$\eta = \frac{w_{net}}{q_{in}}$$

$$w_{net} = w_t - w_p = 1332 - 4.98 = 1327$$

$$\eta = \frac{1327}{3541} = 0.35 = 35\%$$

10-48]

$$p = 20 \text{ kPa}$$

$$h_1 = 281.1 \text{ kJ/kg}$$

$$v_1 = 0.001 \text{ m}^3/\text{kg}$$

$$p_2 = 3000 - 20 = 2980 \text{ kPa}$$

$$w_p = 0.001 (2980)$$

$$w_p = 3 \frac{\text{kJ}}{\text{kg}}$$

$$h_2 = h_1 + w_p$$

$$h_2 = 284.1$$

$$p_3 = 3000 \text{ kPa}$$

$$h_2 = 3115$$

$$t_3 = 350^\circ\text{C}$$

$$s_3 = 6.74$$

$$s_4 = s_3$$

$$h_5 = 2408 \frac{\text{kJ}}{\text{kg}}$$

$$y = (h_4 - h_6) = h_7 - h_2$$

$$h_6 = h_7 = 762$$

$$y (2850 - 762) = (762 - 284)$$

$$y = 0.243$$

$$w_f = (h_2 - h_4) + (1 - y)(h_4 - h_5)$$

$$3115 - 2850 = 265$$

$$2850 - 2408 = 442$$

$$(1 - 0.243)(442) = 336$$

$$w_f = 265 + 336$$

$$w_f = 601 \frac{\text{kJ}}{\text{kg}}$$

$$q_{in} = h_3 - h_1$$

$$q_{in} = 3115 - 281 = 2353 \frac{\text{kJ}}{\text{kg}}$$

10-53

$$CFWH = 1.2 \text{ MPa}$$

$$CFWH = 0.6 \text{ MPa}$$

Boiler 10 MPa, 600°C

$$\text{condens} = 10 \text{ kPa}$$

$$W = 400 \text{ MW}$$

$$P = 10 \text{ kPa}$$

$$h_1 = 191.8 \frac{\text{kJ}}{\text{kg}}$$

$$W_p = v(P_2 - P_1)$$

$$W_p = 0.001(600 - 10) = 0.59$$