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Problem 8.2

Given: - Water in an ideal Rankine Cycle
- Superheated Vapor enters the turbine at 8MPa & 480°C
- Condenser pressure is 8KPa
- Net power output is 100 MW

Determine: (a) Rate of heat transfer through the steam generator
(b) Thermal Efficiency
(c) The mass flow rate for the cooling water if it enters at 15°C & exits at 35°C

Process 1-2

$$\frac{\dot{W}_t}{\dot{m}} = h_1 - h_2$$

Table A-4 @ $T_1 = 480°C$ & $P_1 = 80\,bar$
$h_1 = 3348.4\ kJ/kg$, $s_1 = s_2 = 6.6586\ kJ/kg\cdot K$

Table A-3 @ $P_2 = 8kPa = 0.08\,bar$
$s_{f2} = 0.5926\ kJ/kg\cdot K$, $s_{g2} = 8.2287\ kJ/kg\cdot K$
$h_{f2} = 173.88\ kJ/kg$, $h_{g2} = 2577.0\ kJ/kg$

$$x_2 = \frac{6.6586 - 0.5926}{8.2287 - 0.5926} = 0.7944$$

$$h_2 = 173.88 + 0.7944(2577 - 173.88) = 2082.92\ kJ/kg$$

$$\frac{\dot{W}_t}{\dot{m}} = 3348.4 - 2082.88 = \boxed{1265.52\ kJ/kg}$$

Process 2-3

$$\frac{\dot{Q}_{out}}{\dot{m}} = h_2 - h_3 \qquad h_3 = h_{f2} = 173.88\ kJ/kg$$

$$\frac{\dot{Q}_{out}}{\dot{m}} = 2082.92 - 173.88 = \boxed{1909.04\ kJ/kg}$$

Process 3-4

$$\frac{\dot{W}_p}{\dot{m}} = h_4 - h_3 \qquad v_3 = v_{2f} = 1.0084\times10^{-3}\ m^3/kg$$

$$= v_3(P_4 - P_3) = (1.0084\times10^{-3})(8000\,kPa - 8\,kPa)$$

$$= 8.059\ kJ/kg$$

Problem 8.2

$$h_4 = h_3 + \frac{\dot{W}_P}{\dot{m}} = 173.88 + 8.059 = 181.94 \text{ kJ/kg}$$

Process 4-1

$$\frac{\dot{Q}_{in}}{\dot{m}} = h_1 - h_4 = 3348.4 - 181.94 = 3166.46 \text{ kJ/kg}$$

$$\dot{m} = \frac{\dot{W}_{cycle}}{\dot{W}_t/\dot{m} - \dot{W}_P/\dot{m}} = \frac{100 \times 10^3 \text{ kW}}{1265.52 \text{ kJ/kg} - 8.059 \text{ kJ/kg}}$$

$$\boxed{\dot{m} = 79.53 \text{ kg/s}}$$

$$\dot{Q}_{in} = (79.53)(3166.46) = \boxed{251.8 \times 10^3 \text{ kW}}$$

$$\eta = \frac{\dot{W}_{cycle}}{\dot{Q}_{in}} = \frac{100 \times 10^3 \text{ kW}}{251.8 \times 10^3 \text{ kW}} = 0.397$$

$$\boxed{\eta = 39.7\%}$$

Problem 9.11

Given: Air-Standard Otto Cycle with compression ratio of 7.5

- $P_1 = 85\,kPa$ & $T_1 = 32°C$, $m = 2g$
- Max temp is 960K

Determine:
(a) Heat rejection
(b) net work
(c) Thermal Efficiency

Process 1-2

$$\frac{W_{12}}{m} = u_2 - u_1$$

Table A-22 @ T = 305 K
$u_1 = 217.67\,kJ/kg$, $v_{r_1} = 596.0$

$$v_{r_2} = \frac{v_{r_1}}{r} = \frac{596.0}{7.5} = 79.47$$

Interpolating in Table A-22, $u_2 = 486.77\,kJ/kg$

$$\frac{W_{12}}{m} = 486.77 - 217.67 = \boxed{269.1\,kJ/kg}$$

Process 2-3

$$\frac{Q_{23}}{m} = u_3 - u_2$$

$T_{max} = 960K = T_3$
Table A-22 ⇒ $u_3 = 725.02\,kJ/kg$
$v_{r_3} = 28.40$

$$\frac{Q_{23}}{m} = 725.02 - 486.77 = \boxed{238.25\,kJ/kg}$$

$$v_{r_4} = r\,v_{r_3} = (7.5)(28.40) = 213$$

Process 3-4

$$\frac{W_{34}}{m} = u_3 - u_4$$

Interpolating in Table A-22 with $v_{r_4} = 213$ ⇒ $u_4 = 329.01\,kJ/kg$

$$= 725.02 - 329.01$$

$$\boxed{\frac{W_{34}}{m} = 396.01\,kJ/kg}$$

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Process 4-1

$\frac{Q_{41}}{m} = u_4 - u_1 = 329.01 - 217.67 = \boxed{111.34\,kJ/kg}$

(a) $Q_{41} = (0.002\,kg)(111.34\,kJ/kg) = \boxed{0.2227\,kJ}$

(b) $W_{cycle} = (0.002\,kg)(396.01 - 269.1)$

$\boxed{W_{cycle} = 0.2538\,kJ}$

(c) $\eta = \frac{W_{cycle}/m}{Q_{23}/m} = \frac{0.2538\,kJ}{(0.002\,kg)(238.25\,kJ/kg)}$

$\eta = 0.533 = \boxed{53.3\%}$

(1)

Problem 10.10

Given:
- Refrigerant 22 in an ideal vapor-compression refrigeration cycle
- Compressor temperature is $-40°C$ (T_1)
- Volumetric Flow rate is $15\ m^3/min$
- Condenser Temp is $32°C$ & on exit Pressure is 9 bar

Determine:
(a) Compressor Power
(b) Refrigerating Capacity
(c) Coefficient of Performance

Process 1-2s

$$\frac{\dot{W}_c}{\dot{m}} = h_{2s} - h_1$$

Table A-7 @ $T_1 = -40°C$
$h_1 = h_g = 233.27\ kJ/kg$
$s_1 = s_2 = s_g = 1.0005\ kJ/kg \cdot K$

State 2 => S

Interpolating in Table A-9 with $s_2 = 1.0005$ & $P_2 = 9\ bar$ => $h_{2s} = 287.54\ kJ/kg$

$$\frac{\dot{W}_c}{\dot{m}} = 287.54 - 233.27 = \boxed{54.27\ kJ/kg}$$

Process 2s-3

$$\frac{\dot{Q}_{out}}{\dot{m}} = h_{2s} - h_3$$

Table A-7 @ $T_3 = 32°C$
$h_3 = h_{f3} = 84.14\ kJ/kg$

$$\frac{\dot{Q}_{out}}{\dot{m}} = 287.54 - 84.14 = \boxed{203.4\ kJ/kg}$$

Process 3-4

$$h_4 = h_3 = 84.14\ kJ/kg$$

Process 4-1

$$\frac{\dot{Q}_{in}}{\dot{m}} = h_1 - h_4 = 233.27 - 84.14\ kJ/kg$$

$$= \boxed{149.13\ kJ/kg}$$

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Problem 10.10

$\dot{m} = \frac{(A V_1)}{v_1}$ Table A-7 $v_1 = 0.2052 m^3/kg$

$= \frac{15 m^3/min}{0.2052 m^3/kg} = 73.1 kg/min = 1.22 kg/s$

(a) $\dot{W}_c = (1.22 kg/s)(54.27 kJ/kg) = \boxed{66.2 kW}$

(b) $\dot{Q}_{in} = (73.1 kg/min)(149.13 kJ/kg) = 10,901 kJ/min$

$\boxed{\dot{Q}_{in} = 51.67 \text{ tons}}$

(c) $\beta = \frac{\dot{Q}_{in}/\dot{m}}{\dot{W}_c/\dot{m}} = \frac{149.13}{54.27} = \boxed{2.75}$