# ME 200 Homework 4

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### Due: Sep 27 Edit: September 24, 2024

1.

$$\nu_1 = \nu_2 = 0.4625 \text{ kg/m}^3$$

$$\frac{2960.9 - 2963.2}{0.4397 - 0.6173} = 12.9505$$

$$0.4397 \times 12.9505 + 2960.9 = 2961.2 \text{ kJ/kg}$$

$$Q = (2961.2 - 2553.6) \times 1 = \boxed{407.595 \text{ kJ/kg}}$$

2.

$1 \rightarrow 2$:

$$Q = mT(s_2 - s_1) = 1 \times (503.23 + 459.67) \times (1.4305 - 0.6927) = \boxed{710.428 \text{ Btu}}$$

$$W = 710.428 - (1117 - 488.9) = \boxed{82.32 \text{Btu}}$$

$2 \rightarrow 3$:

$$6.20x + (1-x)0.01748 = 0.656$$

$$x = 0.1032$$

$$u_3 = xu_g + (1-x)u_f = 358.114 \text{ Btu/lb}$$

$$Q = m(u_3 - u_2) = \boxed{-758.886}$$

$$W = \boxed{0}$$

$3 \rightarrow 4$:

$$s_3 = x_3 s_g + (1-x_3)s_f = 0.5642$$

$$6.20x_4 + (1-x_4)0.01748 = 0.02501$$

$$x_4 = 0.001218$$

$$s_4 = x_4 s_g + (1-x_4)s_f = 0.44265$$

$$u_4 = x_4 u_g + (1-x_4)u_f = 273.608$$

$$Q = mT(s_4 - s_3) = 1 \times (302.96 + 459.67)(0.44265 - 0.5642)$$

$$= \boxed{-92.6973 \text{ Btu}}$$

$$W = Q - m(u_4 - u_3) = -92.6973 - 273.608 + 358.114 = \boxed{-8.1918 \text{ Btu}}$$

$4 \rightarrow 1$:

$$Q = m(u_1 - u_4) = \boxed{215.292 \text{ Btu}}$$

$$w = \boxed{0 \text{ Btu}}$$

$$\eta = q - \frac{Q_{out}}{Q_{in}} = 1 - \frac{758.886 + 92.6973}{710.428 + 215.292} = 0.080085$$

3.

$1 \rightarrow 2$: Since isothermal, $W = pv\ln(\frac{v_2}{v_1}) = 5 \times 10^5 \times \ln(\frac{5}{1}) = 804719$ J/kg

$2 \rightarrow 3$:

$$T_2 = \frac{Pv}{nR} = \frac{10^5 \times 5}{\frac{1}{28.97 \times 10^{-3}} \times 8.314} = 1742.24 \text{ K}$$

$$T_3 = \frac{Pv}{nR} = \frac{10^5}{286.987} = 348.448 \text{ K}$$

$$u_2 = \frac{1439.8 - 1392.7}{1750 - 1700} \times 42.24 + 1392.7 = 1432.49 \text{ kJ/kg}$$

$$u_3 = \frac{250.02 - 242.82}{350 - 340} \times 8.448 + 242.82 = 248.903 \text{ kJ/kg}$$

$$W = p\Delta V = 10^5 \times -4 = -4 \times 10^5 \text{ J/kg}$$

$$Q = Q - W + W = (u_3 - u_2) + W = -1.58359 \times 10^6 \text{J/kg}$$

$3 \rightarrow 1$:

$$T_1 = \frac{Pv}{nR} = \frac{5 \times 10^5}{286.987} = 1742.24 \text{ K}$$

$$u_1 = \frac{1439.8 - 1392.7}{1750 - 1700} \times 42.24 + 1392.7 = 1432.49 \text{ kJ/kg}$$

$$Q = m(u_1 - u_3) = 1432.49 - 248.903 = 1183.59 \text{kJ/kg}$$

$$\eta = 1 - \frac{Q_{out}}{Q_{in}} = \frac{1.58359 \times 10^5}{1183.59 \times 10^3 + 804719} = \boxed{0.20355}$$

4.

in: $\frac{20 \times 10 \times 10^{-3}}{0.1996} = 1.002$ kg/s

exit: $\frac{1 \times 6 \times 10^{-3}}{1.905 \times 10^{-3}} = 5.50206$ kg/s

total: $1.002 - 5.50206 = \boxed{-4.5006 \text{ kg/s}}$

5.    a) $v = RT/p = 286.987 \times 450/350 \times 10^3 = 0.3689$ m$^3$/kg

      $A = \frac{mv}{V} = 2.3 \times 0.3689/3 = 0.2829$ m$^2$

    b) $\Delta Q = \Delta U + \Delta E_v - \Delta W = m\Delta T c_p + 0.5m(\Delta v)^2 - 0$

      $= 2.3 \times (1.011 \times 10^3(300 - 450) + 0.5 \times (460^2 - 3^2)) = -105465 =$

      $\boxed{-105.465 \text{ kW}}$