Contents

Pset1

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Problem 1

First Law: $\dot{E}_{sys} = \dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} + \Delta\dot{E}_{flow}$

In the given problem,

$\dot{Q}_{in} = \dot{Q}_H, \quad \dot{Q}_{out} = \dot{Q}_C$

$\dot{W}_{out} = \dot{W}, \quad \dot{W}_{in} = 0$

$\Delta\dot{E}_{flow} = 0, \ \ \dot{E}_{sys} = 0$

a)

$\dot{E}_{sys} = (500 - 300) + (0 - 200) + 0 = 0$

Therefore, the first law holds

b)

$\dot{E}_{sys} = (400 - 120) + (0 - 280) + 0 = 0$

Therefore, the first law holds

c)

$\dot{E}_{sys} = (650 - 500) + (0 - 300) + 0 = -150 \neq 0$

Therefore, the first law does not hold

d)

$\dot{E}_{sys} = (200 - 800) + (0 - 600) + 0 = -1200 \neq 0$

Therefore, the first law does not hold

Problem 2

In the given problem,

$\kappa_A = 20\ W/m.K, \quad L_A = 0.30m$

$\kappa_B = ?\ W/m.K, \quad L_B = 0.15m$

$\kappa_C = 50\ W/m.K, \quad L_C = 0.15m$

$T_0 = 800°C, \quad T_1 = 600°C, \quad T_4 = 20°C$

$h = 25\ W/m^2.K, \quad A = 2m^2$

a)

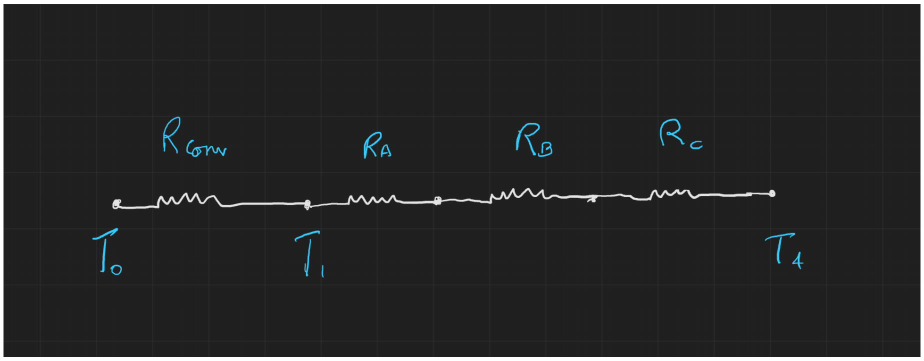

Figure 1: Thermal Resistivity Diagram

b)

$$\dot{Q} = hA(T_h - T_c) = 25 \times 2(800 - 600) = 10,000W$$

$$R_A = \frac{L_A}{\kappa_A A} = \frac{0.3}{20 \times 2} = 0.0075K/W$$

$$R_B = \frac{L_B}{\kappa_B A} = \frac{0.15}{\kappa_B \times 2} = \frac{0.075}{\kappa_B}K/W$$

$$R_C = \frac{L_C}{\kappa_C A} = \frac{0.15}{50 \times 2} = 0.0015K/W$$

$$R_{conv} = \frac{1}{hA} = \frac{1}{25 \times 2} = 0.02K/W$$

$$R_{total,condution} = R_A + R_B + R_C = (0.009 + \frac{0.075}{\kappa_B})K/W$$

$$\dot{Q} = \frac{\Delta T}{R_{total,conduction}}$$

$$10,000 = \frac{600 - 20}{0.009 + \frac{0.075}{\kappa_B}}$$

On solving this equation, $\kappa_B = 1.53 W/m.K$

c)

$$R_{total} = R_{conv} + R_A + R_B + R_C = 0.02 + (0.009 + \frac{0.075}{1.53}) K/W = 0.078 K/W$$

$R_{total} = 0.078 K/W$

Problem 3

$T_1 = 1400K, \quad P_1 = 20\ bar$

$T_2 = 1100K, \quad P_2 = 5\ bar$

$T_3 = ?\ K, \quad P_3 = 4.5\ bar$

$T_4 = 980K, \quad P_4 = 1\ bar$

$T_5 = 1480K, \quad P_5 = 1.35\ bar, \quad m_5 = 1200kg/min$

$T_6 = 1200K, \quad P_6 = 1\ bar$

a)

In the given problem, for the state going from 5 to 6:

$\dot{E}_{sys} = \Delta\dot{Q} + \Delta\dot{W} + \Delta\dot{E}_{flow}$

$\dot{E}_{sys} = 0W, \quad \Delta\dot{Q} = \Delta\dot{Q}_{5,6}, \quad \Delta\dot{W} = 0W, \quad \dot{E}_{flow} = \dot{m}(h_5 - h_6)$

$\dot{m} = 20kg/s, \quad h_5 = 1611.79kJ/kg.K, \quad h_6 = 1277.79kJ/kg.K$

$0 = \Delta\dot{Q}_{5,6} + 0 + 20(1611.79 - 1277.79)$

$\Delta\dot{Q}_{5,6} = -6680kW$

In the given problem, for the state going from 1 to 2:

$\dot{E}_{sys} = \Delta\dot{Q} + \Delta\dot{W} + \Delta\dot{E}_{flow}$

$\dot{E}_{sys} = 0W, \quad \Delta\dot{Q} = 0W, \quad \Delta\dot{W} = -10,000KW, \quad \dot{E}_{flow} = m(h_1 - h_2)$

$h_1 = 1515.42kJ/kg.K, \quad h_2 = 1161.07kJ/kg.K$

$0 = 0 - 10000 + m(1515.42 - 1161.07)$

$m = 28.22$

In the given problem, for the state going from 2 to 3:

$\dot{E}_{sys} = \Delta\dot{Q} + \Delta\dot{W} + \Delta\dot{E}_{flow}$

$\dot{E}_{sys} = 0, \quad \Delta\dot{Q} = \Delta\dot{Q}_{5,6} = 6680, \quad \Delta\dot{W} = 0, \quad \dot{E}_{flow} = 28.22(h_2 - h_3)$

$h_2 = 1161.07kJ/kg.K$

$0 = 6680 + 28.22(1161.07 - h_3)$

$h_3 = 1397.78$

=> $T_3 = 1301.52K$

b)

In the given problem, for the state going from 3 to 4:

$\dot{E}_{sys} = \Delta\dot{Q} + \Delta\dot{W} + \Delta\dot{E}_{flow}$

$\dot{E}_{sys} = 0, \quad \Delta\dot{Q} = 0, \quad \Delta\dot{W} = 0, \quad \dot{E}_{flow} = 28.22(h_3 - h_4)$

$h_3 = 1397.78kJ/kg.K, h_4 = 1023.25kJ/kg.K$

$0 = 0 + \Delta\dot{W} + 28.22(1397.78 - 1023.25)$

$\dot{W}_{out} = 10569.24kW$