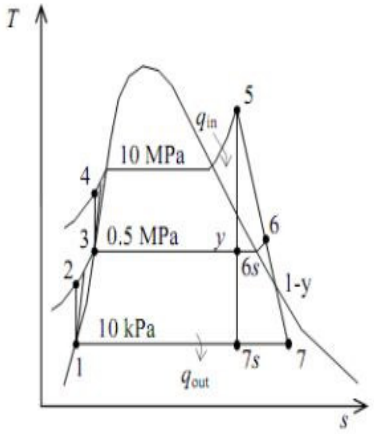
پاسخ سوال ۱



(a) From the steam tables (Tables A-4, A-5, and A-6),

$$h_1 = h_{f\,@\,10\,\text{kPa}} = 191.81\,\text{kJ/kg}$$
$$v_1 = v_{f\,@\,10\,\text{kPa}} = 0.00101\,\text{m}^3/\text{kg}$$

$$w_{\text{pI,in}} = v_1(P_2 - P_1)/\eta_p$$
$$= (0.00101\,\text{m}^3/\text{kg})(500-10\,\text{kPa})\left(\frac{1\,\text{kJ}}{1\,\text{kPa}\cdot\text{m}^3}\right)/(0.95)$$
$$= 0.52\,\text{kJ/kg}$$
$$h_2 = h_1 + w_{\text{pI,in}} = 191.81 + 0.52 = 19233\,\text{kJ/kg}$$

$$\left.\begin{array}{l} P_3 = 0.5\,\text{MPa} \\ \text{satliquid} \end{array}\right\} \begin{array}{l} h_3 = h_{f\,@\,0.5\,\text{MPa}} = 640.09\,\text{kJ/kg} \\ v_3 = v_{f\,@\,0.5\,\text{MPa}} = 0.001093\,\text{m}^3/\text{kg} \end{array}$$

$$w_{\text{pII,in}} = v_3(P_4 - P_3)/\eta_p$$
$$= (0.001093\ \text{m}^3/\text{kg})(10{,}000 - 500\ \text{kPa})\left(\frac{1\,\text{kJ}}{1\,\text{kPa}\cdot\text{m}^3}\right)/(0.95)$$
$$= 10.93\ \text{kJ/kg}$$
$$h_4 = h_3 + w_{\text{pII,in}} = 640.09 + 10.93 = 651.02\ \text{kJ/kg}$$

$$\left.\begin{array}{l} P_5 = 10\,\text{MPa} \\ T_5 = 500°\text{C} \end{array}\right\} \begin{array}{l} h_5 = 3375.1\,\text{kJ/kg} \\ s_5 = 6.5995\,\text{kJ/kg}\cdot\text{K} \end{array}$$

$$\left.\begin{array}{l} P_{6s} = 0.5\,\text{MPa} \\ s_{6s} = s_5 \end{array}\right\} \begin{array}{l} x_{6s} = \dfrac{s_{6s} - s_f}{s_{fg}} = \dfrac{6.5995 - 1.8604}{4.9603} = 0.9554 \\ h_{6s} = h_f + x_{6s}h_{fg} = 640.09 + (0.9554)(2108.0) \\ \quad = 2654.1\,\text{kJ/kg} \end{array}$$

$$\eta_T = \frac{h_5 - h_6}{h_5 - h_{6s}} \longrightarrow h_6 = h_5 - \eta_T(h_5 - h_{6s})$$
$$= 3375.1 - (0.80)(3375.1 - 2654.1)$$
$$= 2798.3\ \text{kJ/kg}$$

$$\left.\begin{matrix} P_{7s}=10\text{ kPa} \\ s_{7s}=s_5 \end{matrix}\right\} \begin{matrix} x_{7s}=\dfrac{s_{7s}-s_f}{s_{fg}}=\dfrac{6.5995-0.6492}{7.4996}=0.7934 \\ h_{7s}=h_f+x_{7s}h_{fg}=191.81+(0.7934)(2392.1) \\ =2089.7\text{ kJ/kg} \end{matrix}$$

$$\eta_T=\frac{h_5-h_7}{h_5-h_{7s}} \longrightarrow \begin{matrix} h_7=h_5-\eta_T(h_5-h_{7s}) \\ =3375.1-(0.80)(3375.1-2089.7) \\ =2346.8\text{ kJ/kg} \end{matrix}$$

The fraction of steam extracted is determined from the steady-flow energy balance equation applied to the feedwater heaters. Noting that $\dot{Q}\cong\dot{W}\cong\Delta ke\cong\Delta pe\cong 0$,

$$\dot{E}_{\text{in}}-\dot{E}_{\text{out}}=\Delta\dot{E}_{\text{system}}^{\nearrow 0\,(\text{steady})}=0$$

$$\dot{E}_{\text{in}}=\dot{E}_{\text{out}}$$

$$\sum\dot{m}_i h_i=\sum\dot{m}_e h_e \longrightarrow \dot{m}_6h_6+\dot{m}_2h_2=\dot{m}_3h_3 \longrightarrow yh_6+(1-y)h_2=1(h_3)$$

where y is the fraction of steam extracted from the turbine ($=\dot{m}_6/\dot{m}_3$). Solving for y,

$$y=\frac{h_3-h_2}{h_6-h_2}=\frac{640.09-192.33}{2798.3-192.33}=0.1718$$

Then, $q_{\text{in}}=h_5-h_4=3375.1-651.02=2724.1\text{ kJ/kg}$

$$q_{\text{out}}=(1-y)(h_7-h_1)=(1-0.1718)(2346.8-191.81)=1784.7\text{ kJ/kg}$$

$$w_{\text{net}}=q_{\text{in}}-q_{\text{out}}=2724.1-1784.7=939.4\text{ kJ/kg}$$

and

$$\dot{m}=\frac{\dot{W}_{\text{net}}}{w_{\text{net}}}=\frac{150{,}000\text{ kJ/s}}{939.4\text{ kJ/kg}}=\mathbf{159.7\text{ kg/s}}$$

(*b*) The thermal efficiency is determined from

$$\eta_{\text{th}}=1-\frac{q_{\text{out}}}{q_{\text{in}}}=1-\frac{1784.7\text{ kJ/kg}}{2724.1\text{ kJ/kg}}=\mathbf{34.5\%}$$

پاسخ سوال ۲

صفحه ۵۰۳

پاسخ سوال ۳

$$m_m = m_{O_2} + m_{N_2} + m_{CO_2} = 5\,\text{kg} + 8\,\text{kg} + 10\,\text{kg} = 23\,\text{kg}$$

$$\text{mf}_{O_2} = \frac{m_{O_2}}{m_m} = \frac{5\,\text{kg}}{23\,\text{kg}} = \mathbf{0.217} \qquad N_{O_2} = \frac{m_{O_2}}{M_{O_2}} = \frac{5\,\text{kg}}{32\,\text{kg/kmol}} = 0.156\,\text{kmol}$$

$$\text{mf}_{N_2} = \frac{m_{N_2}}{m_m} = \frac{8\,\text{kg}}{23\,\text{kg}} = \mathbf{0.348} \qquad N_{N_2} = \frac{m_{N_2}}{M_{N_2}} = \frac{8\,\text{kg}}{28\,\text{kg/kmol}} = 0.286\,\text{kmol}$$

$$\text{mf}_{CO_2} = \frac{m_{CO_2}}{m_m} = \frac{10\,\text{kg}}{23\,\text{kg}} = \mathbf{0.435} \qquad N_{CO_2} = \frac{m_{CO_2}}{M_{CO_2}} = \frac{10\,\text{kg}}{44\,\text{kg/kmol}} = 0.227\,\text{kmol}$$

$$N_m = N_{O_2} + N_{N_2} + N_{CO_2} = 0.156\,\text{kmol} + 0.286\,\text{kmol} + 0.227\,\text{kmol} = 0.669\,\text{kmol}$$

and

$$y_{O_2} = \frac{N_{O_2}}{N_m} = \frac{0.156\,\text{kmol}}{0.699\,\text{kmol}} = \mathbf{0.233}$$

$$y_{N_2} = \frac{N_{N_2}}{N_m} = \frac{0.286\,\text{kmol}}{0.669\,\text{kmol}} = \mathbf{0.428}$$

$$y_{CO_2} = \frac{N_{CO_2}}{N_m} = \frac{0.227\,\text{kmol}}{0.669\,\text{kmol}} = \mathbf{0.339}$$

(*c*) The average molar mass and gas constant of the mixture are determined from their definitions:

$$M_m = \frac{m_m}{N_m} = \frac{23\,\text{kg}}{0.669\,\text{kmol}} = \mathbf{34.4\,kg/kmol}$$

and

$$R_m = \frac{R_u}{M_m} = \frac{8.314\,\text{kJ/kmol}\cdot\text{K}}{34.4\,\text{kg/kmol}} = \mathbf{0.242\,kJ/kg\cdot K}$$

تعداد سؤالات: تستی: تشریحی: ۵ زمان آزمون (دقیقه): تستی: تشریحی: ۱۲۰

نام درس: ترمودینامیک ۲

رشته تحصیلی/ کُد درس: کارشناسی مهندسی راه آهن- جریه ۱۳۱۵۱۷۵

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استفاده از: ماشین حساب مهندسی وکتاب باز مجاز است.

پاسخ سوال ۴

صفحه ۵۷۷

پاسخ سوال ۵

مشابه مثال ۱۴-۲

صفحه ۶۰۹