Colby Watts
Professor Ayala
MET 350 HW 1.4
2/6/2024

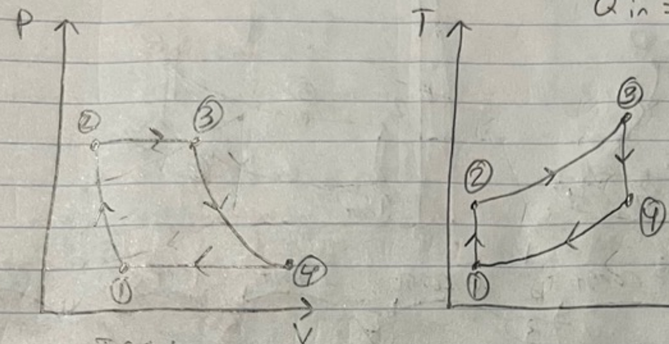
HW 1.4 Ch 9. 88, 99, 107, 119, 121

$C_v = 0.717926 \ kJ/kg\cdot K$

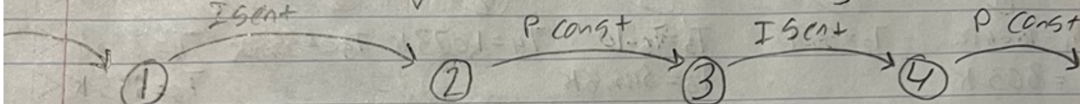
9.88 - Const C_P, C_v at room Temp $C_P = 1.004926 \ kJ/kg\cdot K$

$Q_{in} = 500 \ kW$ $k = 1.4$

$r_p = 10 = \frac{P_2}{P_1}$



$\boxed{\text{Power Produced} \ \& \ \eta_{th}}$



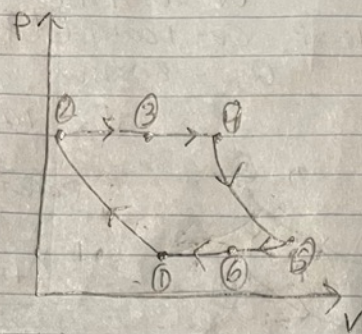
$P_1 = 70 \ kPa$
$T_1 = 273 \ K$

$$\eta_{th,\,Brayton} = 1 - \frac{1}{r_p^{(k-1)/k}} = 1 - \frac{1}{10^{.4}}$$

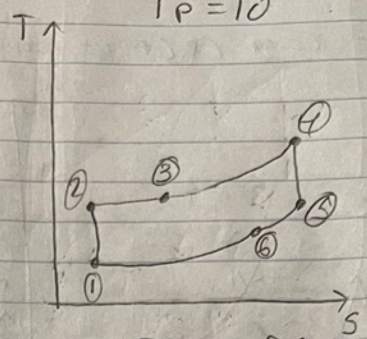
$$\boxed{\eta_{th} = 0.482 = 48.2\%}$$

$$\text{Power Produced} = (Q_{in})(\eta_{th}) = (500)(.482) = \boxed{241 \ kW}$$

9.99



$r_p = 10$



isent → P const → P const → Isent → P const

① → ② → ③ → ④ → ⑤ → ⑥

$P_1 = 100\,kPa$, $T_1 = 303\,K$ | $T_2 = 585\,K$ | $T_3 = T_5 - 10$, $T_3 = 545.8\,K$ | $T_4 = 1{,}073\,K$ | $T_5 = 555.8\,K$ | $T_6 = ?$, $T_6 = 595\,K$

$$\frac{T_2}{T_1} = 10^{\frac{1.4-1}{1.4}} = 585\,K \qquad \frac{T_4}{T_5} = (10)^{\frac{1.4-1}{1.4}}$$

$$W_C = m\,C_P(T_2 - T_1) = (1.005)(585 - 303) = 283$$

$$W_T = m\,C_P(T_4 - T_5) = (1.005)(1{,}073 - 555.8) = 519.716$$

$$P = W_{net} \quad W_T - W_C = 520 - 283 =$$

$$P = 115\,KW \qquad m = 0.4865\,kg/s$$

$$Q_{in} = m\,C_P(T_4 - T_3) = (0.4865\,kg/s)(1.005\,kJ/kg\cdot K)(1{,}073\,K - 545.8\,K)$$

$$\boxed{Q_{in} = 258\,KW}$$

$$T_5 - T_6 = T_3 - T_2$$

$$T_6 = -T_3 + T_2 + T_5 = -546 + 585 + 556 = 595$$

$$T_6 = 595\,K$$

$$Q_{out} = m \cdot C_P(T_6 - T_1)$$

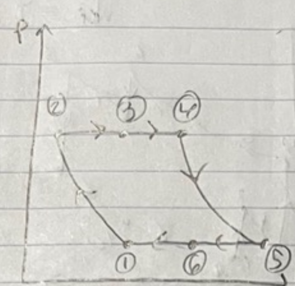
$$Q_{out} = (0.4865\,kg/s)(1.005\,kJ/kg\cdot K)(595 - 303)$$

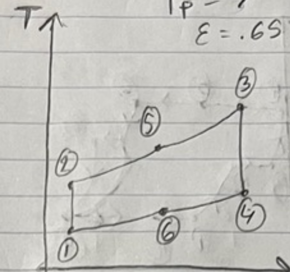
$$\boxed{Q_{out} = 143\,KW}$$

9.107 -

$r_p = 7$ $\quad \eta_c = .75$

$\varepsilon = .65$ $\quad \eta_{th} = .82$





$① \xrightarrow{\text{isent}} ② \xrightarrow{\text{P const}} ③ \xrightarrow{\text{P const}} ④ \xrightarrow{\text{Isent}} ⑤ \xrightarrow{\text{P const}} ⑥ \xrightarrow{\text{P const}}$

$T_1 = 310K$ $\quad P_2 = 10.88$ $\quad T_3 = 1150K$

Table A-17 $P_1 = 1.5546$ kPa

$P_2 = (P_r)(P_1)$

$h_1 @ 310K = 310.24$ kJ/kg (Table A-17)

$h_3 @ 1150K = 1219.25$ kJ/kg (used interpolation calculator) Table A-17

$P_{r3} @ 1150K = 200.15$

$10.88 = h_{2s} = 541.26$ kJ/kg $\qquad h_2 = h_1 + \left(\frac{h_{2s} - h_1}{\eta_c}\right) = 310.24\left(\frac{541.26 - 310.24}{.75}\right)$

$h_2 = 616.3$ kJ/kg

$P_{r4} \overset{P_{r3}}{=} \left(\frac{1}{7}\right)(200.15) \overset{h_{4s}}{=} 710.80$ kJ/kg

$h_4 = h_3 - \eta_{th}(h_3 - h_{4s}) = 1219.25$ kJ/kg $- .85(1219.25 - 710.80)$

$h_4 = 803.14$ kJ/kg

$W_{net} = W_{out} - W_{in} = (h_3 - h_4) - (h_2 - h_1)$

$W_{net} = (1219.25$ kJ/kg $- 803.14$ kJ/kg$) - (616.3$ kJ/kg $- 310.24$ kJ/kg$)$

$\boxed{W_{net} = 108 \text{ kJ/kg}}$

$h_5 = h_2 + \varepsilon(h_4 - h_2) = (618.3 \text{ kJ/kg}) + .65(803.14 - 618.3)$ kJ/kg $= 738.43$ kJ/kg

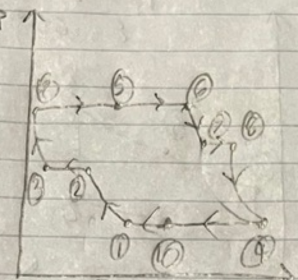
$h_5 = 738.43$

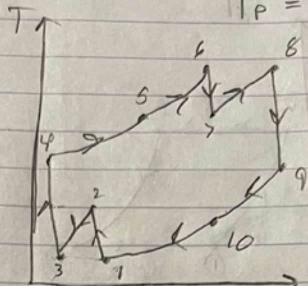
$q_{in} = h_3 - h_5 = (1219.25 - 783.43) = 481$ kJ/kg

$\boxed{\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{108}{481} = .225 = 22.5\ \%}$

9.119 –

$r_p = 9$ $\quad W_{net} = 110\,MW$





$\rightarrow 1 \xrightarrow{isent} 2 \xrightarrow{P\ const} 3 \xrightarrow{Isen} 4 \xrightarrow{P\ const} 5 \xrightarrow{P\ const} 6 \xrightarrow{Isent} 7 \xrightarrow{P\ const} 8 \xrightarrow{Isen} 9 \xrightarrow{P\ const} 10 \xrightarrow{P\ const}$

$T_1 = 300K$ $\qquad T_3 = 300K$

$h_1 = 300.19\ kJ/kg \quad h_2 = 411.25\ kJ/kg$

$Pr_1 = 1.386$

$T_1 = T_3 \quad h_1 = h_3$ $\qquad T_6 = T_8 \quad h_6 = h_8$

$T_7 = T_9 \quad h_7 = h_9$

$T_2 = T_4 \quad h_2 = h_4$

$$\frac{Pr_2}{Pr_1} = \frac{P_2}{P_1} = \sqrt{9} \quad Pr_2 = \sqrt{9} \cdot 1.386 = 4.158$$

$h_1 = h_3 = 300.19\ kJ/kg \quad h_2 = h_4 = 411.25\ kJ/kg \quad h_6 = h_8 = 1277.79\ kJ/kg$

$h_7 = h_9 = 946.35\ kJ/kg$

$$W_{Turbine} = (h_6 - h_7) - (h_8 - h_9)$$

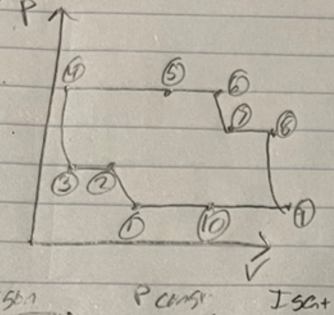
$$W_T = 222.12\ kJ/kg$$

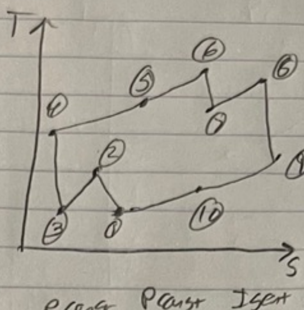
$$W_{net} = W_T - W_C \quad W_{net} = 662.88 - 222.12 = 440.76\ kJ/kg$$

$$W_{out} = m\,W_{net} = m = \frac{W_{out}}{W_{net}} = \frac{110\ MW}{440.76}$$

$$0.2496 = \boxed{250\ kJ/s}$$

9.121





$r_p = 3$

$\varepsilon = .75$

$\rightarrow 1 \xrightarrow{\text{Isen}} 2 \xrightarrow{\text{P const}} 3 \xrightarrow{\text{Isent}} 4 \xrightarrow{\text{P const}} 5 \xrightarrow{\text{P const}} 6 \xrightarrow{\text{Isent}} 7 \xrightarrow{\text{P const}} 8 \xrightarrow{\text{Ise}} 9 \xrightarrow{\text{P const}} 10 \xrightarrow{\text{P const}}$

$T_1 = 300K$

$h_1 = 300.19\ kJ/kg$

$T_5 = 1200K$

$h_5 = h_7 = 1277.79\ kJ/kg \quad P_{r_5} = 238$

$P_{r_1} = 1.386 \quad P_{r_2} = 4.158 \quad h_2 = h_4 = 411.26\ kJ/kg$

$P_{r_6} = (\frac{1}{3})(238) = 79.33$

$h_6 = h_8 = 946.36\ kJ/kg$

$w_C = w_{in} = 2(h_2 - h_1) = 222.14\ kJ/kg$

$w_T = w_{out} = 2(h_5 - h_6) = 662.88\ kJ/kg$

$$B.W.R. = \frac{w_C}{w_T} = \frac{222.14}{662.88} = .335 = 33.5\%$$

$q_{in} = (h_5 - h_4) + (h_7 - h_6) = 1197.96\ kJ/kg$

$w_{net} =$ problem 9.119 $= 440.76\ kJ/kg$

$$\eta_{th} = \frac{w_{net}}{q_{in}} = \frac{440.76}{1197.96} = 36.8\%$$