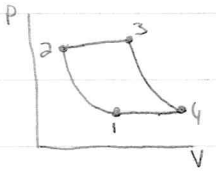
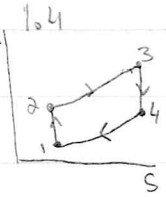
Jordan Whitaker
2/8/19

HW 10.4

(88)





$R = 0.287\ kJ/kg\cdot K$

$C_p = 1.005\ kJ/kg\cdot K$

$C_v = 0.718\ kJ/kg\cdot K$

$k = 1.4$

$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$

$\frac{T_2}{273} = (10)^{\frac{1.4-1}{1.4}}$

$T_2 = 527.08\ K$

$\dot{Q}_{in} = \dot{m} C_p (T_3 - T_2)$

$500 = 1(1.005)(T_3 - 527)$

$T_3 = 1024.5\ K$

$\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$

$\frac{T_4}{1024.5} = \left(\frac{1}{10}\right)^{\frac{1.4-1}{1.4}}$

$T_4 = 530.637\ K$

$W_{net} = m(W_T - W_C) \Rightarrow m[C_p(T_3 - T_4) - C_p(T_2 - T_1)]$

$= 1.005(493.86 - 254.08)$

$= 240.98\ kW$

$\eta_{th} = \frac{W_{net}}{\dot{Q}_{in}}$

$= \frac{240.98}{500}$

$= 48.19\%$

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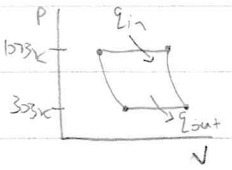

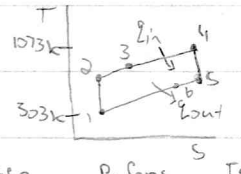

$T_2 = T_1 r_p^{(k-1)/k}$

$T_2 = (303)(10)^{\frac{1.4-1}{1.4}}$

$= 585\ K$

$T_5 = T_4 \left(\frac{1}{r_p}\right)^{\frac{(k-1)}{k}}$

$T_5 = (1073)\left(\frac{1}{10}\right)^{\frac{1.4-1}{1.4}}$

$= 555.6\ K$

$T_3 = T_5 - 10$

$= 555.8 - 10$

$= 545.8\ K$

Cont. →

$T_6 = T_5 - (T_3 - T_2)$

$= 555.8 - [545.8 - 585]$

$= 595 K$

$W_{net} = C_p(T_4 - T_5) - C_p(T_2 - T_1)$

$= 1.005(1073 - 555.8) - 1.005(585 - 303)$

$= 236.4 kJ/kg$

$\dot{m} = \frac{\dot{W}_{net}}{W_{net}}$

$= \frac{115 kW}{236.4}$

$= 0.486 kg/s$

$\dot{Q}_{in} = \dot{m} C_p (T_4 - T_3)$

$= 0.486 \cdot 1.005 (1073 - 545.8)$

$= 258 kW$

$\dot{Q}_{out} = \dot{m} C_p (T_6 - T_1)$

$= 0.486 \cdot 1.005 (595 - 303)$

$= 143 kW$

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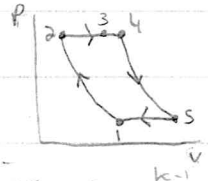

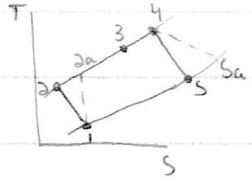

$T_2 = T_1 r_p^{\frac{k-1}{k}}$

$T_2 = 310 (7)^{\frac{1.4-1}{1.4}}$

$T_2 = 310 (1.744)$

$= 540.5 K$

$\eta_c = \frac{T_2 - T_1}{T_{2a} - T_1} \Rightarrow 0.75 = \frac{542.5 - 310}{T_{2a} - 310}$

$T_{2a} = 617.4 K$

Sub T_5 →

$T_5 = (r_p)^{\frac{T_4}{k}}$

$\varepsilon = \frac{T_3 - T_{2a}}{T_{5a} - T_{2a}} \Rightarrow 0.85 = \frac{T_3 - 617.4}{747.8 - 617.4}$

$T_3 = 728.2 K$

$T_5 = \frac{1150}{(7)^{\frac{1.4-1}{1.4}}}$

$= 659.5 K$

$$\eta_T = \frac{T_4 - T_{5a}}{T_4 - T_5}$$

$$0.82 = \frac{1150 - T_{5a}}{1150 - 659.5}$$

$$\boxed{T_{5a} = 747.8\,K}$$

$$w_{net} = w_T - w_C$$

$$= C_p(T_4 - T_{5a}) - C_p(T_{2a} - T_1)$$

$$= 1.005(1150 - 747.8) - 1.005(617.4 - 540.5)$$

$$\boxed{= 95.28\ kJ/kg}$$

$$q_{in} = C_p(T_4 - T_3)$$

$$= 1.005(1150 - 702.2)$$

$$= 450.07\ kJ/kg \Rightarrow \eta_{th} = \frac{w_{net}}{q_{in}}$$

$$= \frac{95.28}{450.1} \times 100$$

$$\boxed{= 21.2\%}$$

MET 350

HW 1.4

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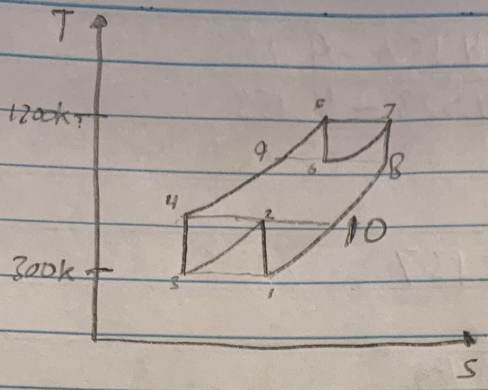


$$\frac{P_2}{P_1} = \frac{P_4}{P_3} = \sqrt{9} = 3$$

$$\frac{P_6}{P_5} = \frac{P_7}{P_8} = \sqrt{9} = 3$$

$h_1 = 300.19\ kJ/kg$

$P_{r1} = 1.3860$

$T_5 = 1200K$

$h_5 = 1277.79\ kJ/kg$

$P_{r5} = 238$

$$P_{r2} = \frac{P_2}{P_1} P_{r1}$$

$= (3)(1.3860)$

$P_{r2} = 4.158$

$h = 421.26\ kJ/kg$

$$\frac{h_2 - 411.12}{421.26 - 411.12} = \frac{4.158 - 4.153}{4.522 - 4.153}$$

$$h_2 - 411.12 = 0.137$$

$$h_2 = 411.267 \text{ kJ/kg}$$

$$P_{r6} = \frac{P_6}{P_5} P_{r5}$$

$$= \frac{1}{3}(258)$$

$$= 79.\overline{3}$$

$$P_r = 75.29$$
$$h = 932.93 \text{ kJ/kg}$$

$$P_r = 82.05$$
$$h = 955.38 \text{ kJ/kg}$$

$$\frac{h_6 - 932.93}{955.38 - 932.93} = \frac{79.33 - 75.29}{82.05 - 75.29}$$

$$h_6 - 932.93 = 13.427$$

$$h_6 = 946.357 \text{ kJ/kg}$$

$(W_{comp,in} = 2(h_2 - h_1)$

$= 2(411.257 - 300.19)$

$= 222.134 kJ/kg$

$(W_{turbine})_{out} = 2(h_3 - h_4)$

$= 2(1277.9 - 946.357)$

$= 622.866 kJ/kg$

$W_{net} = 622.866 kJ/kg - 222.134 kJ/kg$

$= 440.732 kJ/kg$

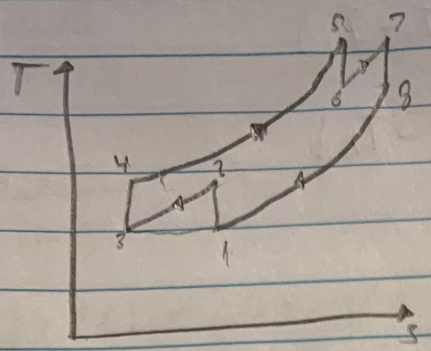
$\dot{W} = \dot{m} W_{net}$

$110 \times 10^3 = \dot{m}(440.732 kJ/kg)$

$\boxed{\dot{m} = 250 kg/s}$

HW 1.4

1-121



$$\frac{P_2}{P_1} = \frac{P_4}{P_3} = 8$$

$$\frac{P_5}{P_6} = \frac{P_7}{P_8} = 8$$

$$P_1 = 14.16 \text{ lbf/in}^2$$

$$T_1 = T_3 = 70\text{F} = 529.67\text{R}$$

$$T_5 = T_7 = 2000\text{F} = 2459.67\text{R}$$

$$\left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_1}{T_2} \qquad \left(\frac{P_5}{P_6}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_5}{T_6}$$

$$\left(\frac{1}{8}\right)^{\frac{1.4-1}{1.4}} = \frac{529.67}{T_2} \qquad \left(8\right)^{\frac{1.4-1}{1.4}} = \frac{2459.67}{T_6}$$

$$T_2 = 960.039\text{R} \qquad T_6 = 1357.041\text{R}$$

$$= T_4 \qquad = T_8$$

$$w_c = C_p(T_1 - T_2) + C_p(T_3 - T_4)$$

$$= C_p(T_1 - T_2) + C_p(T_1 - T_2)$$

$$= 2C_p(T_1 - T_2)$$

$$= 2(0.24)(529.67 - 960.039)$$

$$w_c = -206.577 \text{ Btu/lbm}$$

$$w_T = C_p(T_5 - T_6) + C_p(T_7 - T_8)$$

$$= C_p(T_5 - T_6) + C_p(T_5 - T_6)$$

$$= 2C_p(T_5 - T_6)$$

$$= 2(0.24)(2459.67 - 1357.041)$$

$$\boxed{w_T = 529.261 \text{ Btu/lbm}}$$

$$T_8 = T_x$$

$$q_H = C_p(T_5 - T_x) + C_p(T_7 - T_6)$$

$$= C_p(T_5 - T_8) + C_p$$

$$q_H = 529.261 \text{ Btu/lbm}$$

$$\eta = \frac{W_{net}}{q_H}$$

$$= \frac{W_T + W_C}{q_H}$$

$$= \frac{529.261 - 206.527}{519.261}$$

$$= 0.6096$$

$$\boxed{\eta = 60.96\ \%}$$