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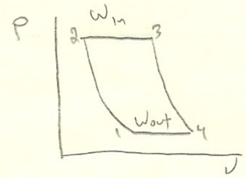
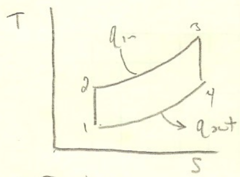
#88) $r_p = 10$ $\dot{Q}_{in} = 500$ kW $\dot{m} = 1$ kg/s $T_1 = 0°$ $P_1 = 70$ kpa

Find: P_{out} & η Assume specific heats





$\dot{Q} \times \dot{m}$/s

kJ/s × kg/s → kJ/kg

1 —Isen.→ 2 —Tconst→ 3 —Isen.→ 4 —Pconst.→

1	2	3	4
$T_1 = 273k$	$P_2 = 10P_1 = 700$ kpa	$P_3 = 700$ kpa	$P_4 = 70$ kpa
$P_1 = 70$ kpa	$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$	$\dot{Q}_{in} \times \dot{m} = \dot{m}C_p(T_3 - T_2)$	$T_4 = T_3\left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$
	$T_2 = 273(10)^{\frac{1.4-1}{1.4}}$	$500 \times 1 = 1(1.005)(T_3 - 527.1k)$	$T_4 = 1024.6k\left(\frac{70}{700}\right)^{\frac{1.4-1}{1}}$
	$T_2 = 527.1k$	$T_3 = 1024.6k$	$T_4 = 530.7k$

$q_{out} = C_p(T_4 - T_1) = 1.005(530.7k - 273k) = 259$ kJ/kg

$W_{net} = q_{in} - q_{out} = 500$ kJ/kg $- 259$ kJ/kg $=$ **$W_{net} = 241$ kJ/kg**

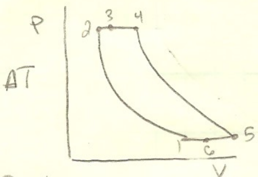
W_{net} @ $\dot{m} = 1$ kg/s $= 241$ kJ/kg × 1 kg/s = **$W_{net} = 241$ kW**

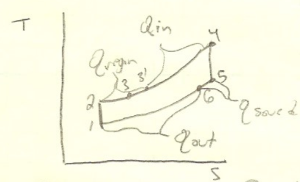
$\eta = \frac{W_{net}}{q_{in}} = \frac{241 \text{ kJ/kg}}{500 \text{ kJ/kg}}$ **$\eta = 48.2\%$**

#49 $P_1 = 100\,kpa$ $T_1 = 30°c$ $r_p = 10$ $T_{max} = 800°c$ $\Delta t = 10°c$ $P_{out} = 115\,kW$

Find Q_{in} & Q_{out}

Counter flow → $T_5 - T_3 = \Delta T$





1 → Isen.	2 → Pconst.	3 → Pconst.	4 → Isen.	5 → Pconst.	6
$T_1 = 30°c + 273k$	$P_2 = r_p P_1 = 100(10)$	$P_3 = P_2 = 1000\,kpa$	$P_4 = P_3 = 1000\,kpa$	$P_5 = P_6 = 100\,kpa$	$P_6 = P_1 = 100\,kpa$
$T_1 = 303k$	$P_2 = 1000\,kpa$	$T_3 = T_5 - \Delta T$	$T_4 = T_{max} = 800°c + 273$	$T_5 = T_4\left(\frac{P_5}{P_4}\right)^{\frac{k-1}{k}}$	$q_{in} = q_{out} \to C_p(T_5 - T_6) = C_p(T_3 - T_2)$
$P_1 = 100\,kpa$	$T_2 = T_1(r_p)^{\frac{k-1}{k}}$	$T_3 = 555.8 - 10$	$T_4 = 1073k$	$= 1073k\left(\frac{100}{1000}\right)^{\frac{1.4-1}{1.4}}$	$T_6 = T_5 + T_2 - T_3$
	$T_2 = 303(10)^{\frac{1.4-1}{1.4}}$	$T_3 = 545.8k$		$T_5 = 555.8k$	$= 555.8k + 585k - 545.8k$
	$T_2 = 585k$				$T_6 = 595k$

$q_{in} = C_p(T_4 - T_3) = 1.005(1073k - 545.8k) = 529.83\,kj/kg \times .49\,kg/s = 259.6\,kW$

$q_{out} = C_p(T_6 - T_1) = 1.005(595k - 303k) = 293.46\,kj/kg \times .49\,kg/s = 143.8\,kW$

$W_{net} = q_{in} - q_{out} = 529\,kj/kg - 293.46\,kj/kg = 236.37\,kj/kg$

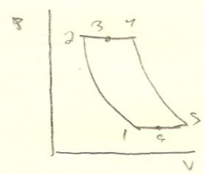
$\frac{kj/s}{kj/kg} = kg/s = \dot{m} = \frac{P_{out}}{W_{net}} = \frac{115\,k\dot{W}}{236.37\,kj/kg}$ $\dot{m} = .49\,kg/s$

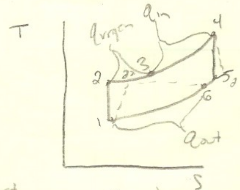
#107

$r_p = 7$ $T_{min} = 310k$ $T_{max} = 1150k$ $\eta_{comp} = 75\%$ $\eta_{turbine} = 82\%$ $\varepsilon = 65\%$

Find = T_5, W_{net}, $\eta_{thermal}$

* Assume variable C_p & C_v *





1	Isen → 2s & 2a	Pconst → 3	Pconst → 4	Isen → 5s & 5a	Pconst → 6	Pconst →
$T_1 = 310k$ from A-17 $P_{r1} = 1.5546$ $h_1 = 310.24$ kj/kg	$\frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}}$ $7(1.5546) = P_{r2}$ $P_{r2} = 10.88$ Interpolate between 530 & 540 k for T_2 & h_2 $T_2 = 536.98k$ $h_{2s} = 541.22$ kj/kg		$T_4 = 1150k$ Interpolate between 1140k & 1160k $h_4 = 1219.25$ $P_{r4} = 200.15$	$\frac{P_5}{P_4} = \frac{P_{r5}}{P_{r4}}$ $\frac{(200.15)}{7} = P_{r5}$ $P_{r5} = 28.6$ Interpolate between 690 & 700k for h_5 & T_5 $T_5 = 698.7k$ $h_{5s} = 711.85$		

$\eta_T = \frac{(h_4 - h_{5a})}{(h_4 - h_{5s})}$ solve for h_{5a} since actual temp is needed

$h_{5a} = h_4 - \eta_T(h_4 - h_{5s}) = 1219.25\,kj/kg - .82(1219.25\,kj/kg - 711.85\,kj/kg)$

$h_{5a} = 803.2\,kj/kg$

Interpolate between 780 & 800k with $h = 803.2\,kj/kg$ for T_5 = $\boxed{T_5 = 782.9k}$

$W_{net} = (h_{2a} - h_1) - (h_4 - h_{5a})$ → $\eta_c = \frac{h_{2s} - h_1}{h_{2a} - h_1}$ → solve for h_{2a}

must find h_{2a}

$h_{2a} = \frac{h_{2s} - h_1}{\eta} + h_1$

$h_{2a} = \frac{541.22\,kj/kg - 310.24}{.75} + 310.24$

$h_{2a} = 618.21$

$W_{net} = (618.21\,kj/kg - 310.24\,kj/kg) - (1219.25 - 803.2\,kj/kg)$

$\boxed{W_{net} = 108.08\,kj/kg}$

$$\eta = \frac{W_{net}}{q_{in}} \qquad q_{in} = h_4 - h_3 \rightarrow \text{need to find } h_3$$

$$\epsilon = \frac{h_3 - h_{2a}}{h_{5a} - h_{2a}}$$

$$h_3 = \epsilon(h_{5a} - h_{2a}) + h_{2a}$$

$$= .65(803.2 \text{ kj/kg} - 618.21 \text{ kj/kg}) + 618.21$$

$$h_3 = 738.5 \text{ kj/kg}$$

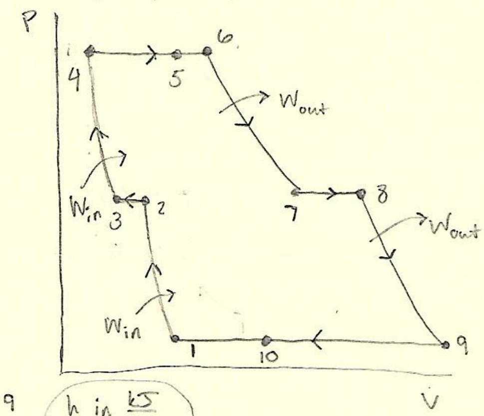
$$q_{in} = 1219.25 \text{ kj/kg} - 738.5 \text{ kj/kg}$$

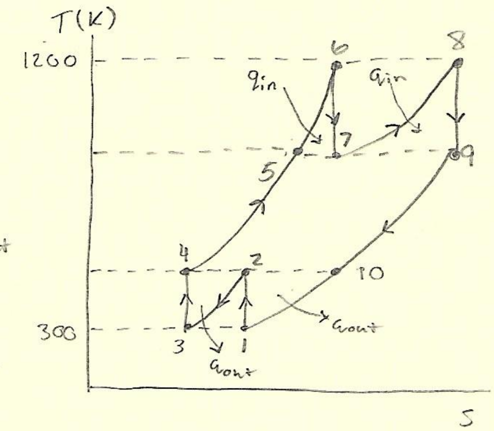
$$q_{in} = 480.8 \text{ kj/kg}$$

$$\eta = \frac{108.08 \text{ kj/kg}}{480.8 \text{ kj/kg}} \times 100 \qquad \boxed{\eta_{th} = 22.5\%}$$

119) Givin : $W_{net} = 110MW$ — Pressure Ratio = 9 $W = J/s$

- 2 compression
- 2 expansion





$r_p = 9$ h in $\frac{kJ}{kg}$

Processes:

①→ isentropic →②→ Isobaric →③→ Isentropic →④→ Isobaric →⑤→⑥→ Isentropic →⑦→ Isobaric →⑧→ Isentropic →⑨→ Isobaric →⑩

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
$T_1 = 300k$	$T_2 = 410$	$T_3 = 300k$	$T_4 = T_2$	$T_5 =$	$T_6 = 1200k$	$T_7 = 911.95$	$T_8 = 1200k$	$T_9 = T_7$	$T_{10} =$
~~$P_1 =$~~	~~$P_2 =$~~	~~$P_3 = P_2$~~	~~$P_4 =$~~	~~$P_5 = P_4$~~	~~$P_6 = P_4$~~	~~$P_7 =$~~	~~$P_8 =$~~	~~$P_9 =$~~	$P_{10} = P_9$
$P_{r1} = 1.386$	$P_{r2} = 4.158$	$P_{r3} = 1.386$	$P_{r4} = P_{r2}$	$P_{r5} =$	$P_{r6} = 238$	$P_{r7} = 79.3$	$P_{r8} = 238$	$P_{r9} = 79.3$	$P_{r10} =$
~~$V_1 =$~~	~~$V_2 =$~~	~~$V_3 =$~~	~~$V_4 =$~~	~~$V_5 =$~~	~~$V_6 =$~~	~~$V_7 =$~~	~~$V_8 =$~~	~~$V_9 =$~~	~~$V_{10} =$~~
$h_1 = 300.19 \frac{kJ}{kg}$	$h_2 = 411.26$	$h_3 = 300.19$	$h_4 = 411.26$	$h_5 =$	$h_6 = 1277.79$	$h_7 = 946.35$	$h_8 = 1277.79$	$h_9 = h_7$	$h_{10} =$

$\frac{P_2}{P_1} = \sqrt{9} = 3 \longrightarrow \frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}} \longrightarrow 3(1.386) = P_{r2} = 4.158 \longrightarrow T_2$ = by interpolation App

Temps (410–420 k) and P_r's (4.153 – 4.522) $T_2 = 410.14\,k$

$h_2 = \frac{(410.14 - 410)(421.26 - 411.12)}{(420 - 410)} + 411.12 = 411.26\ kJ/kg$

$\frac{P_4}{P_3} = 3 = \frac{P_{r4}}{P_{r3}} \longrightarrow P_{r4} = 4.158 = P_{r2} \longrightarrow T_2 = T_4 \longrightarrow h_2 = h_4$

$\frac{P_6}{P_7} = \frac{P_8}{P_9} = 3 \longrightarrow \frac{P_6}{P_7} = \frac{P_{r6}}{P_{r7}} \longrightarrow \frac{P_{r6}}{3} = P_{r7} = 79.3 \longrightarrow T_7 = \frac{(79.3 - 75.29)(920 - 900)}{(82.05 - 75.29)} + 900$

$T_7 = 911.95\,k \longrightarrow h_7 = \frac{(911.95 - 900)(955.38 - 932.93)}{(920 - 900)} + (932.93)$ $h_7 = 946.35\ kJ/kg$

$W_{in_{net}} = \Delta h_{1\to2} + \Delta h_{3\to4} = (411.26 - 300.19)(2) = 222.14\ kJ/kg$

$W_{out_{net}} = \Delta h_{6\to7} + \Delta h_{8\to9} = 2(1277.79 - 946.35) = 662.88\ kJ/kg$

$W_{net} = 662.88 - 222.14 = 440.74\ kJ/kg \longrightarrow m = \frac{110 \times 10^3\ kW}{440.74\ kJ/kg} = \frac{110 \times 10^3\ kJ/s}{440.74\ kJ/kg}$

$\boxed{m = 249.58\ kg/s}$

Carter Fishback/Hannon French

121) Given:

a.) - No Regenerator
- Find thermal Efficiency, η_{TH}, and Back work, r_{BW}

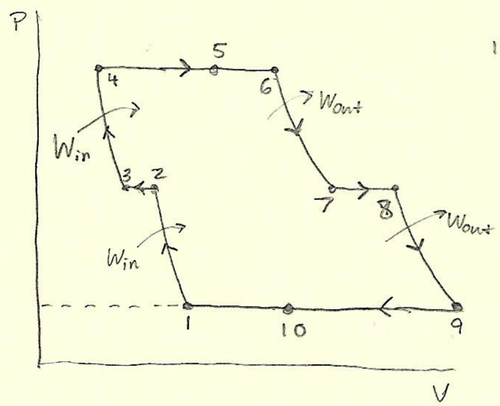
b.) - Regenerator w/ $\eta_{reg} = .75$
- find η_{TH} and r_{BW}

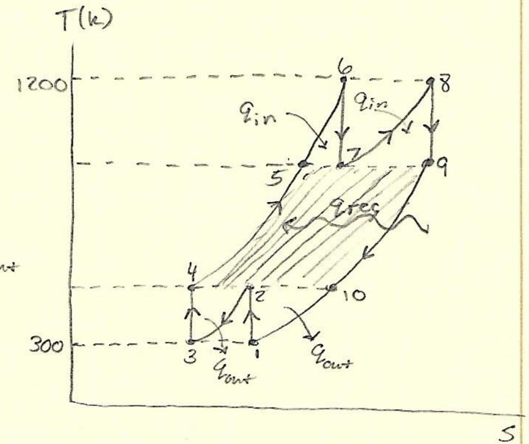
Key Equations:

$W = \Delta h$ $\qquad r_p = 3$ (@ each stage)

$r_{BW} = \frac{W_{comp_{in}}}{W_{turb_{out}}}$ $\qquad$ - When $\eta_{regen} = 100\%$, then

$\eta_{TH} = \frac{W_{net}}{q_{in}}$





① $\xrightarrow{Isent}$ ②	$\xrightarrow{Pconst}$ ③	$\xrightarrow{Isent}$ ④	$\xrightarrow[Regen.]{Pconst}$ ⑤	$\xrightarrow[q_{in}]{Pconst}$ ⑥	$\xrightarrow{isent}$ ⑦	$\xrightarrow[q_{in}]{Pconst}$ ⑧	$\xrightarrow{isent}$ ⑨	$\xrightarrow[regen.]{Pconst}$ ⑩	
$T_1 = 300k$	$T_2 = 410.14k$	$T_3 = 300k$	$T_4 = 410.14$	$T_5 = 911.95k$	$T_6 = 1200k$	$T_7 = 911.95k$	$T_8 = 1200k$	$T_9 = T_7$	$T_{10} =$ T
$P_{r1} = 1.386$	$P_{r2} = 4.158$	$P_{r3} = 1.386$	$P_{r4} = 4.158$	$P_{r5} =$	$P_{r6} = 238$	$P_{r7} = 79.3$	$P_{r8} = 238$	$P_{r9} = 79.3$	$P_{r10} =$ T
$h_1 = 300.19$	$h_2 = 411.26$	$h_3 = 300.19$	$h_4 = 411.26$	$h_5 = 946.35$	$h_6 = 1277.79$	$h_7 = 946.35$	$h_8 = 1277.79$	$h_9 = 946.35$	$h_{10} =$ T

$\frac{P_2}{P_1} = r_p = 3 \longrightarrow 3 = \frac{P_{r2}}{P_{r1}} \longrightarrow \underline{P_{r2} = 4.158}$

$T_2 = \frac{(4.158 - 4.153)(410 - 420)}{(4.522 - 4.153)} + 410 = \underline{410.14k} \longrightarrow h_2 = \frac{(410.14 - 410)(421.26 - 411.12)}{(420 - 410)} + 4$

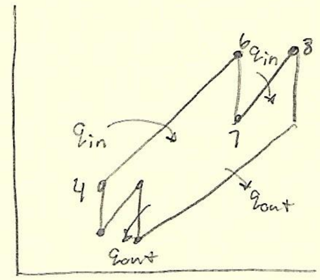
$\underline{h_2 = 411.26 \ kJ/kg}$

$\frac{P_6}{P_7} = 3 = \frac{P_{r6}}{P_{r7}} \longrightarrow P_{r7} = \frac{238}{3} = 79.3$

$T_7 = \frac{(79.3 - 75.29)(920 - 900)}{(82.05 - 75.29)} + 900 = 911.95 \longrightarrow$ $\underline{h_7 = \text{by Interpolation} = 946.35 \ kJ/kg}$

MET 350: Thermo Apps | HW 1.4 | 06-02-2019 Carter Fishback / Hannon French

a.) η_{TH} and r_{BW} w/ NO Regenerator:



$W_{in_{net}} = \Delta h_{1\to2} + \Delta h_{3\to4}$

$= (411.26 - 300.19)(2)$

$W_{in_{net}} = 222.14\ kJ/kg \longrightarrow W_{comp}$

$W_{out_{net}} = \Delta h_{6\to7} + \Delta h_{8\to9}$

$W_{out_{net}} = 662.88\ kJ/kg \longrightarrow W_{turb}$

$q_{in_{net}} = \Delta h_{4\to6} + \Delta h_{7\to8}$

$= (1277.79 - 411.26) + (1277.79 - 946.35)$

$q_{in_{net}} = 1197.97\ kJ/kg$

$r_{BW} = \frac{W_{comp}}{W_{turb}} = \frac{222.14}{662.88}$

$\boxed{r_{BW} = .34}$

$\eta_{TH} = \frac{(W_{out} + W_{in})}{q_{in}} = \frac{440.74}{1197.97}$

$\boxed{\eta_{TH} = .368 = 36.8\%}$

b. η_{TH} and r_{BW} w/ Regenerator:

$\boxed{r_{BW} = .34}$ * Stays the same

$q_{regen} = .75(\Delta h_{4\to5}) = .75(946.35 - 411.26) = 401.32\ kJ/kg$

$q_{in_{net}} - q_{regen} = q_{in_{w/\ Regen\ @\ 75\%}} = 796.65\ kJ/kg$

$\eta_{TH} = \frac{440.74}{796.65}$

$\boxed{\eta_{TH} = .553 = 55.3\%}$

HW 1.3 Grading

#33)

The problem included all three steps, was neat and easy to follow, and had correct answers. Good work. Recommended grade: 100%

#36)

There were not any outstanding errors in your math as you followed Dr. Ayala's test format. The organization of all the mathematical calculations made tracking the problem very easy. It paid off as well since you were also able to obtain the correct solution as well. The only thing I would suggest for the future is to calculate all of the stages separately instead of placing them into such a small table.

Overall, every step was followed to calculate the final answer.

Grade: 100