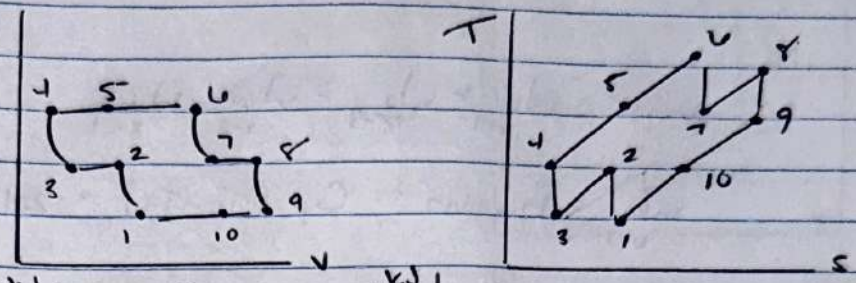
9-123



$r_p = 4$ $\quad C_p = 1.005\ kJ/kg$ $\quad C_v = 0.718\ kJ/kg\text{-}K$ $\quad k = 1.4$

P CONST. 1 → ISENT. 2 → P CONST. 3 → ISENT. 4 → P CONST. REGEN. 5 q_{in}

ISENT. 6 → P CONST. q_{in} 7 → ISENT. 8 → P CONST. REGEN. 9 → 10

1: $P_1 = 100\ kPa$, $T_1 = 17°C \rightarrow 290K$

$v_1 = \frac{RT_1}{P_1} = 0.833$

2: $P_2 = 4(P_1) = 400\ kPa$

$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$, $T_2 = 431.16K$

$v_2 = \frac{RT_2}{P_2} = 0.31$

3: $P_3 = P_2$, $T_3 = T_2$

$v_3 = \frac{RT_3}{P_3} \cdot \frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$, $v_3 = 0.21$

4: $P_4 = 4P_3 = 1600\ kPa$

$v_4 = \frac{RT_4}{P_4} = 0.077$, $T_4 = 431.08K$

5: $P_5 = P_4$, $T_5 = T_4 + 20K = 451.08K$

$v_5 = \frac{RT_5}{P_5} = 0.081$

6: $P_6 = P_5$

$q_{in} = C_p(T_6 - T_5)$

$T_6 = \frac{q_{in}}{C_p} + T_5 = 749.61K$

$v_6 = \frac{RT_6}{P_6} = 0.134$

7: $P_7 = P_2 = 400\ kPa$

$\frac{T_7}{T_6} = \left(\frac{P_7}{P_6}\right)^{\frac{k-1}{k}}$, $T_7 = 504.55K$

$v_7 = \frac{RT_7}{P_7} = 0.362$

8: $P_8 = P_7$, $T_8 = T_7 + q_{in}$

$C_p \frac{T_8}{T_7} = \left(\frac{P_8}{P_7}\right)^{\frac{k-1}{k}}$, $T_8 = 803.08K$

$v_8 = \frac{RT_8}{P_8} = 0.576$

9: $P_9 = P_{10}$, $T_9 = 540.51K$

$v_9 = \frac{RT_9}{P_9} = 1.551$

10: $P_{10} = P_1 = 100\ kPa$

$C_p(T_9 - T_{10}) = C_p(T_5 - T_4)$

$T_{10} = T_9 - \frac{(T_5 - T_4)}{20} = 520.51K$

$v_{10} = 1.494$

$$\eta_{TH} = \frac{W_{NET}}{q_{IN}}$$

$$W_{NET} = W_{O_{6-7}} + W_{O_{8-9}} - W_{IN_{1-2}} - W_{IN_{3-4}}$$

$$W_{O_{6-7}} = h_6 - h_7 = C_p (T_6 - T_7) = 246.267$$

$$W_{O_{8-9}} = h_8 - h_9 = C_p (T_8 - T_9) = 263.863$$

$$W_{IN_{1-2}} = h_2 - h_1 = C_p (T_2 - T_1) = 141.705$$

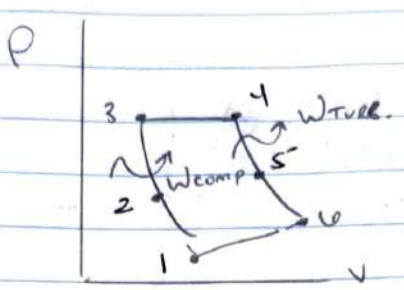
$$W_{IN_{3-4}} = h_4 - h_3 = C_p (T_4 - T_3) = 141.624$$

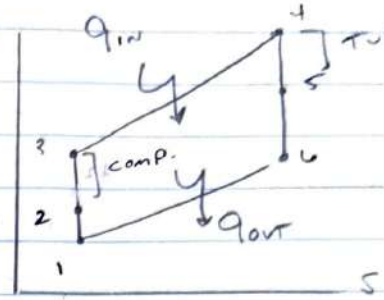
$$W_{NET} = 226.801 \text{ kJ/kg}$$

$$q_{IN} = q_{IN_{5-6}} + q_{IN_{7-8}} = 600 \text{ kJ/kg}$$

$$\boxed{\eta_{TH} = 0.378}$$

9-129E





1 → ISENT. → 2 → ISENT → 3 → $\bar{P}$ = CONST.

4 → ISENT. → 5 → ISENT. → 6 → $\bar{P}$ = CONST.

1
$P_1 = 7\ P_{S1A}$
$T_1 = 10°F \rightarrow 470R$
$V_1 = 900\ ft/s$

2
$T_2 = T_1 + \frac{V_1^2}{2C_p}$
$= 537.4R$
$P_2 = P_1 \left(\frac{T_2}{T_1}\right)^{k/k-1} = 11.19 P_{S1A}$
$V_2 =$

3
$P_3 = 13 P_2 = 145.5 P_{S1A}$
$T_3 = T_2 \left(\frac{P_3}{P_2}\right)^{\frac{k-1}{k}}$
$= 1118R$
$V_3 =$

4
$P_4 = P_3 = 145.5 P_{S1A}$
$T_4 = 2400R$
$V_4 =$

5
$\cancel{q_{4-5}} - w_{4-5} = m(h_5 - h_4)$
$-w_{4-5} = C_p(T_5 - T_4)$
$w_{4-5} = C_p(T_4 - T_5)$
$-C_p(T_2 - T_3) = C_p(T_4 - T_5)$
$T_5 = T_2 - T_3 + T_4 = 1819R$
$P_5 = P_4 \left(\frac{T_5}{T_4}\right)^{k/k-1} = 55.19 P_{S1A}$

6
$P_6 = P_1$
$T_6 = T_5 \left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}}$
$= 1008.6R$

$$Q_{5-6} - W_{5-6} = m\left[(h_6 - h_5) + \frac{1}{2}(V_6^2 - \cancel{V_5^2}^{\,0})\right]$$

$$V_6 = \sqrt{2(h_6 - h_5)} = \sqrt{2 C_p (T_6 - T_5)}$$

$$\boxed{V_6 = 3120.7 \ \frac{ft}{s}}$$

$$\eta_p = \frac{W_p}{P_{in}}$$

$$W_p = (V_6 - V_1) V_1$$

$$= 79.85 \ \frac{Btu}{lbm}$$

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

$$= 307.7 \ \frac{Btu}{lbm}$$

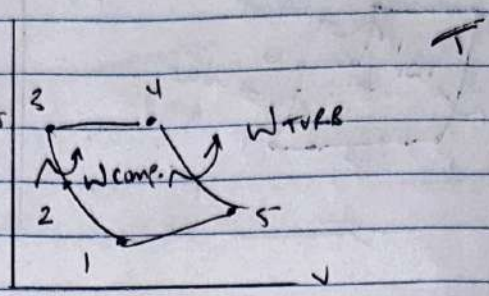
$$= \frac{79.85}{307.7}$$

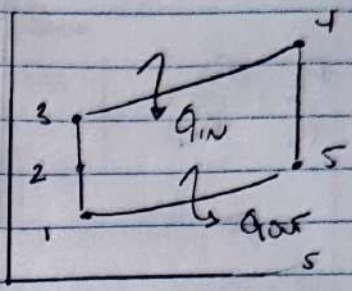
$$\boxed{\eta_p = 0.2591}$$

9-135

$r_p = 9 = \frac{P_2}{P_1}$ P

$P_{IN} = 21{,}350\ kJ/s$





P = CONST. → 1 → ISENT. → 2 → ISENT. → 3 → P = CONST. → 4 → ISNT. → 5

1	2	3	4	5
$T_1 = 280K$	$T_2 = T_1\left(\frac{P_2}{P_1}\right) = 540.4K$	$q_{IN} = h_3 - h_2$	$P_4 = P_3$	$P_5 = P_1$
$P_1 = 95kPa$	$P_{r2} = (9)P_{r1}$	$q_{IN} = \frac{21350}{20} = 1067.5$	$= 855\ kPa$	$= 95kPa$
$h_1 = 280.13$	$= 11.08$	$h_3 = h_2 + q_{IN} = 1611.85$	$h_4 = h_3 - h_2 + 1$	$P_{r5} = P_{r3}\frac{P_5}{P_3}$
$P_{r1} = 1.0889$	$P_2 = \left(\frac{P_{r2}}{P_{r1}}\right)P_1$	$T_3 = 1480.1K$	$= 1347.63$	$= 63.2$
	$= 10.5kPa$	$P_{r3} = 568.8$	$T_4 = 1259.221K$	$T_5 = 860.3K$
	$h_2 = 544.35$	$P_3 = 855kPa$		$h_5 = 888.27$

$V_5 = \sqrt{2(h_4 - h_5)}$

$= \sqrt{2(1347.63 - 888.27)\cdot 1000}$

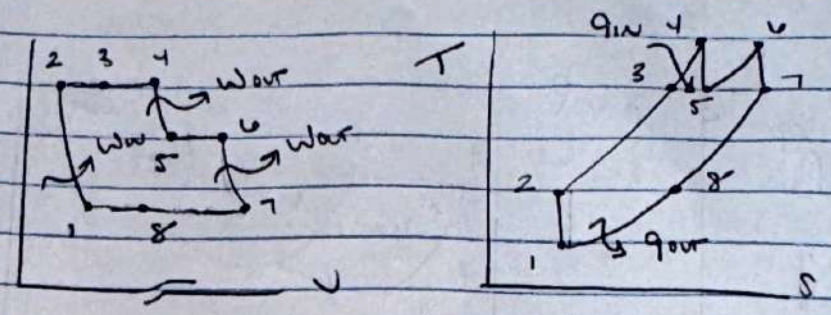
$= 958.5\ m/s$

$F = \dot{m}(V_{EXIT} - V_{IN})$

$= 20(958.5 - 0)$

$F = 19170N$

9-167



$r_p = \frac{P_2}{P_1} \cdot \frac{P_4}{P_5}$

r_p = comp. $\sqrt{r_p}$ = turb.

ISENT. 1 → ISENT. 2 → ISO. 3 → ISO. 4 → ISENT. 5 →

ISO. 6 → ISENT. 7 → ISENT. 8 →

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \rightarrow T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \rightarrow T_1 (r_p)^{k-1/k} = T_8$$

$$\frac{T_5}{T_4} = \left(\frac{P_5}{P_4}\right)^{\frac{k-1}{k}} \rightarrow T_5 = T_4\left(\frac{P_5}{P_5}\right)^{\frac{k-1}{k}} \rightarrow T_4\left(\frac{1}{\sqrt{r_p}}\right)^{\frac{k-1}{k}}$$

$$\rightarrow T_4 r_p^{1-k/2k} = T_3 = T_7$$

$$q_{IN} = h_3 - h_4 = C_p(T_3 - T_4) = C_p(T_3)(1 - r_p^{(1-k)/2k})$$

$$q_{OUT} = h_8 - h_1 = C_p(T_8 - T_1) = C_p(T_1)(r_p^{(k-1)/2k} - 1)$$

$$\eta_{TH} = 1 - \frac{q_{OUT}}{q_{IN}} = 1 - \frac{C_p T_1 (r_p^{k-1/2k} - 1)}{C_p T_3 (r_p^{1-k/2k})}$$

$$\eta_{TH} = 1 - \frac{T_1}{T_3} r_p^{k-1/2k}$$

$$\boxed{\eta_{TH} = 1 - \frac{T_1}{T_3} r_p^{k-1/k}} \quad ???$$