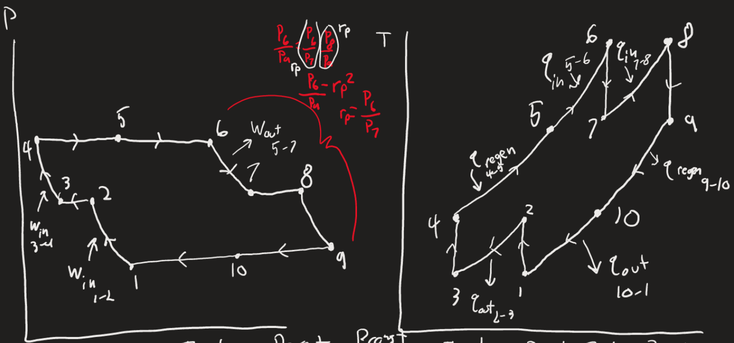
Homework 1.4

Tuesday, February 13, 2024 4:27 PM

9-123



$\frac{P_6}{P_4} = \frac{P_6}{P_7}\frac{P_8}{P_9}$ r_p r_p

$\frac{P_6}{P_4} = r_p^2$

$r_p = \frac{P_6}{P_7}$

1 Isnt 2 Pcnt 3 Isnt 4 Pconst 5 Pconst 6 Isnt 7 Pconst 8 Int 9 Pconsts 10 Pconst

$T_1 = 290K$

$T_2 = T_4 = T_1(r_p)^{k-1/k} = 430.9K$

$T_3 = 290K$

$T_4 = 430.9K$

$T_5 = 250.9K$

$T_6 = T_5 + \frac{q_{in}}{c_p} = 749.4K$

$T_7 = T_6\left(\frac{1}{r_p}\right)^{k-1/k} = 504.3K$

$T_8 = T_7 + \frac{q_{in}}{c_p} = 802.8K$

$T_9 = T_8\left(\frac{1}{r_p}\right)^{k-1/k} = 540.2K$

$T_{10} = T_9 - 20 = 520.2K$

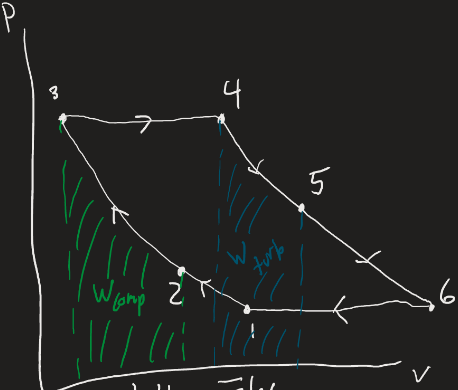
$q_{in} = 300 + 300 = 600 \text{ kJ/kg}$

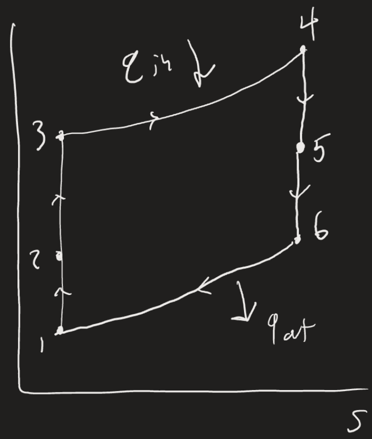
$q_{out} = c_p(T_{10} - T_1) + c_p(T_2 - T_3)$

$= 373.0 \text{ kJ/kg}$

$$\eta_{th} = 1 - \frac{q_{out}}{q_{in}} = 0.378 \text{ or } 37.8\%$$

9-129E





$W_{turb} \equiv W_{comp}$

P I P I I P

1 2 3 4 5 6

$T_1 = 470\text{ R}$

$P_1 = 7\text{ psia}$

$T_2 = T_1 + \frac{V_1^2}{2c_p}$

$= 537.4\text{ R}$

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

$= 11.19\text{ psia}$

$T_3 = T_2 \left(\frac{P_3}{P_2}\right)^{k-1/k}$

$= 1118.3\text{ R}$

$P_3 = P_4$

$= r_p (P_2)$

$= 145.5\text{ Psi}$

$P_4 = 145.5\text{ Psi}$

$T_4 = 2400\text{ R}$

$T_5 = T_4 - T_3 + T_2$

$= 1819.1\text{ R}$

$T_6 = T_5 \left(\frac{P_6}{P_5}\right)^{k-1/k}$

$= 1008.6\text{ R}$

$$E_{in} - E_{out} = \Delta E_{system}$$

$$E_{in} = E_{out}$$

$$h_1 + V_1^2/2 = h_2 + V_2^2/2$$

$$0 = C_p(T_2 - T_1) - V_1^2/2$$

$$0 = cp(T_6 - T_5) + V_6^2/2$$

$$V_6 = \sqrt{2(0.24)(1819.1 - 1008.6)(25037)}$$

$$= 3121 \text{ ft/s}$$

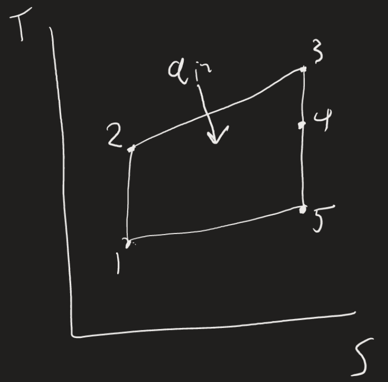
$$w_p = (V_{ex} - V_{in}) V_{air}$$

$$= 79.8 \text{ Btu/lbm}$$

$$q_{in} = h_4 - h_3 = c_p(T_4 - T_3) = 307.6 \text{ Btu/lbm}$$

$$\eta_p = \frac{w_p}{q_{in}} = 0.259 \text{ or } 25.9\%$$

9-135



1

$T_1 = 290\ K$

$h_1 = 290.16$

$P_{r_1} = 1.23$

2

$P_{r_2} = \frac{P_2}{P_1} P_{r1}$

$= 11.08$

$h_2 = 544.07$

3

4

$h_4 = h_3 - h_2 + h_1$

$= 1357.7\ kJ/kg$

5

$P_{r_5} = P_{r_3}\left(\frac{P_5}{P_3}\right)$

$= 63.17$

$h_5 = 888.5\ kJ/kg$

$$\dot{Q}_{in} = \dot{m}_{fuel} \times HV$$

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

$$q_{in} = \frac{\dot{Q}_{in}}{\dot{m}} = 1067.5\ kJ/kg$$

$$q_{in} = h_3 - h_2$$

$$h_3 = 1611.6\ kJ/kg$$

$Pr_3 = 568.5$

$$h_4 + V_4^2/2 = h_5 + V_5^2/2$$

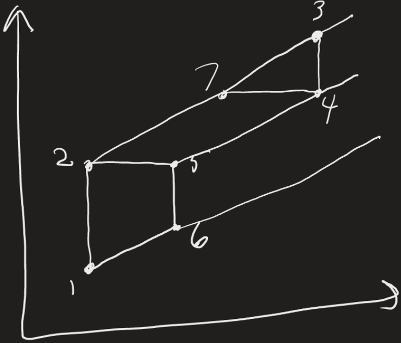
$$0 = h_5 - h_4 + \frac{V_5^2 - \cancelto{0}{V_4^2}}{2}$$

$$V_5 = \sqrt{2(h_4 - h_5)} = 968.6 \text{ m/s}$$

Brake force = Thrust = $\dot{m}(V_{ex} - V_{in})$

$= 19{,}320$ N

9-167



1 2 3 4 5 6 7

$T_7 = T_4 = T_3 \left(\frac{P_1}{P_3}\right)^{\frac{k-1}{k}}$

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

$$T_5 = T_2 = T_1 (r_p)^{\frac{k-1}{k}}$$

$$T_7 = T_4 = T_3 r_p^{(1-k/2k)}$$

$$T_6 = T_1 r_p^{k-1/2k}$$

$$q_{in} = h_3 - h_7 = C_p T_3 \left(1 - r_p^{(1-k/2k)}\right)$$

$$q_{out} = h_6 - h_1 = C_p T_1 \left(r_p^{(k-1/2k)} - 1\right)$$

$$\eta_{th} = 1 - \frac{T_1}{T_3} r_p^{\frac{(k-1)}{k}}$$

2 stages of expansion has a higher thermal efficiency than Single stage expansion.