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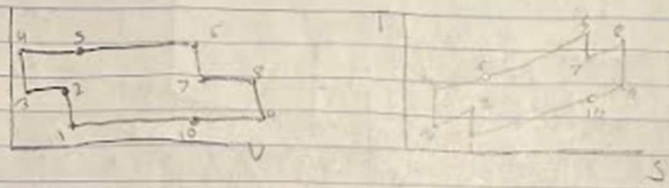

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

$T_1 = 290°K$ $T_2 = 431°K$ $T_3 = 200°K$ $T_4 = 431°K$ $T_5 = 451°K$ $T_6 = 600°K$ $T_7 = 451°K$ $T_8 = 600°K$ $T_9 = 451°K$ $T_{10} = 431°K$

$P_1 = 100 kPa$

$T_2 = T_4 = T_{10}$

$T_6 = T_8$

$T_5 = T_7 = T_9$

$T_2 = T_1 = 17°C = 290°K$

$\frac{P_2}{P_1} = \frac{P_4}{P_3} = 4$

$Q_1 = c_p(T_6 - T_5) + c_p(T_8 - T_7)$

$Q_1 = 2c_p(T_6 - T_5)$

$Q_2 = c_p(T_{10} - T_1) + c_p(T_2 - T_3)$

$Q_2 = 2c_p(T_{10} - T_1)$

$W_{net} = Q_2 - Q_1$

$= 2c_p((T_6 - T_7) - (T_2 - T_1))$

$\eta_{cycle} = 1 - \frac{T_2 - T_1}{T_6 - T_7} = 1 - \frac{T_1}{T_6} \cdot \frac{T_2}{T_1}\left(\frac{1 - \frac{T_1}{T_2}}{1 - \frac{T_7}{T_6}}\right)$

$\eta = 1 - \frac{T_1}{T_6} \cdot \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$

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

$T_2 = 290 \cdot 4^{\frac{1.4-1}{1.4}} = 431°K$

$T_5 = T_4 + 20° \rightarrow 431°K + 20 = 451°K$

$Q_1 = 2c_p(T_6 - T_5) \rightarrow 300 = 2(1.005)(T_6 - 451)$

$T_c = 600°K$

$\eta = 1 - \frac{T_1}{T_c} \cdot \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \rightarrow 1 - \frac{290}{600} \cdot (4)^{\frac{1.4-1}{1.4}}$

$\eta = 0.282 = 28.2\%$

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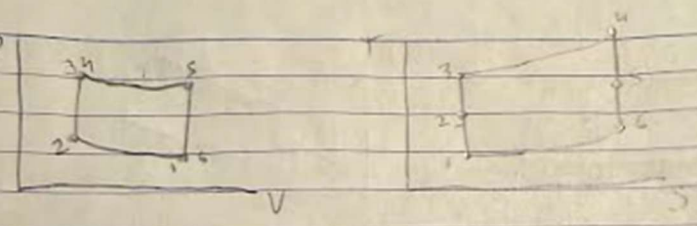

① $T_1 = 470°R$, $P_1 = 7 psia$ ② $T_2 = 537.4°R$, $P_2 = 11.2 psia$ ③ $T_3 = 1118.3°R$, $P_3 = 145.5 psia$ ④ $T_4 = 2400°R$, $P_4 = 145.5 psia$ ⑤ $T_5 = 1819.1°R$, $P_5 = 55.2 psia$ ⑥ $T_6 = 1008.4°R$, $P_6 = 7 psia$

$c_p \cdot T_1 + \frac{V_1^2}{2} = c_p \cdot T_2 \rightarrow T_2 = T_1 + \left(\frac{V_1^2}{2c_p}\right) = 470 + \frac{900^2}{2 \cdot 0.24 \cdot 25037} = 537.4°R$

$P_2 = P_1 \cdot \left(\frac{T_2}{T_1}\right)^{\frac{k}{k-1}} = 7 \cdot \left(\frac{537.4}{470}\right)^{\frac{1.4}{1.4-1}} = 11.2 psia$

$\frac{P_3}{P_2} = 13 \rightarrow P_3 = 11.2 \cdot 13 = 145.5 psia$

$T_3 = T_2\left(\frac{P_3}{P_2}\right)^{\frac{k-1}{k}} = 537.4\left(\frac{145.5}{11.2}\right)^{\frac{1.4-1}{1.4}} = 1118.3°R$

$T_5 = T_4 - (T_3 + T_2) = 2400 - 1118.3 + 537.4 = 1819.1°R$

$P_5 = P_4\left(\frac{T_5}{T_4}\right)^{\frac{k-1}{k}} = 145.5 \cdot \left(\frac{1819.1}{1118.3}\right)^{\frac{1.4}{1.4}} = 55.2 psia$ ← a

$T_6 = T_5\left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}} = 1819.1 \cdot \left(\frac{7}{55.2}\right)^{\frac{0.4}{1.4}} = 1008.4°R$

$V_6 = \sqrt{2c_p(T_5 - T_6)} = \sqrt{2 \cdot 0.24 \cdot (1819.1 - 1008.6) \cdot \frac{25037}{1}} = 3121 ft/s$

$W_p = (V_{exit} - V_{inlet})V_{ac} = (3121 - 900)900 \cdot \frac{1}{25037} = 79.8 \frac{Btu}{lbm}$

$q_{in} = h_4 - h_3 = c_p(T_4 - T_3) = 0.24 \cdot (2400 - 1118.3) = 307.6 \frac{Btu}{lbm}$

$\eta = \frac{W_p}{q_{in}} = \frac{79.8}{307.6} = 0.259 = 25.9\%$ ← c

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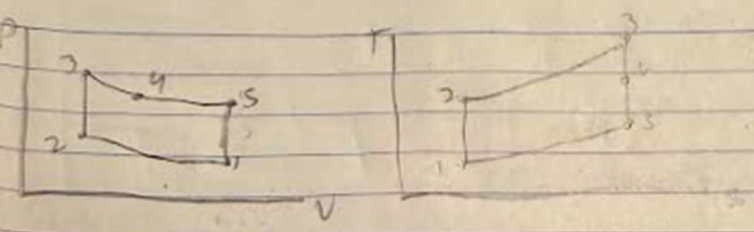

① $T_1 = 280°K$, $P_1 = 95kPa$, $P_{r_1} = 1.0889$

② $T_2 = 521.73K$, $P_{r_2} = 9.8001$

③ $T_3 = 1434.3429°K$, $P_{r_3} = 543.99$

④ $T_4 = 1338.30K$

⑤ $T_5 = 871.3$, $P_{r_5} = 60.4433$

$h_1 = 280.13\ kJ/kg \quad P_{r_1} = 1.0889$

$\frac{P_2}{P_1} = \frac{P_{r_2}}{P_{r_1}} \rightarrow P_{r_2} = P_{r_1}\left(\frac{P_2}{P_1}\right) = 1.0889 \cdot 9 = 9.8001$

$h_2 = \frac{(9.8001 - 9.684)(533.52 - 523.63)}{(10.37 - 9.684)} = 525.3851\ kJ/kg$

$Q_{in} = \dot{m}_{fuel} \cdot h_v = 0.5 \cdot 42700 = 21350\ kW/20 = 1067.5\ kJ/kg$

$Q_{in} = h_3 - h_2 \rightarrow h_3 = 1067.5 + 525.3851 = 1592.88168\ kJ/kg$

$T_3 = \frac{(1592.88168 - 1587.63)(1480 - 1460)}{(1611.29 - 1587.63)} + 1460 = 1684.3423°K$

$P_{r_3} = \frac{(1592.88168 - 1587.63)(551.3102 - 537.1)}{(1611.29 - 1587.63)} + 537.1 = 543.99$

$h_3 - h_4 = h_2 - h_1 \rightarrow h_4 = 1347.63$

$\frac{P_{r_4}}{P_{r_3}} = \frac{v_4}{v_3} \rightarrow P_{r_5} = \frac{P_{r_4}}{9} = 60.4433$

$h_5 = \frac{(60.4433 - 57.6)(881.27 - 866.08)}{(63.09 - 57.6)} + 866.08 = 877.57$

$V_{exit} = \sqrt{2(h_4 - h_5)} = 969.59\ m/s$

$F = \dot{m}_a(v_{exit} - v_{inlet})$

$F = 20(969.59 - 0) = 19391.95\ N$

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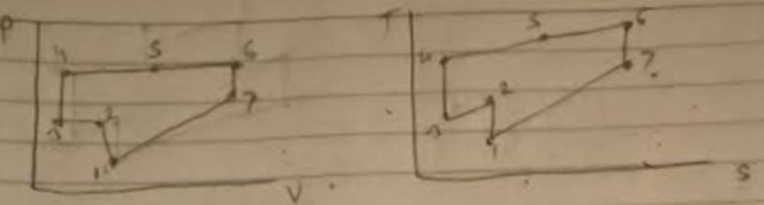

① ② ③ ④ ⑤ ⑥ ⑦

$T_5 = T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = T_1(C)^{\frac{k-1}{k}}$

$T_7 = T_4 = T_3\left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}} = T_3\left(\frac{1}{C}\right)^{\frac{k-1}{k}} = T_3 C^{\frac{1-k}{2k}}$

$T_6 = T_5\left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}} = T_5\left(\frac{1}{C}\right)^{\frac{k-1}{k}} = T_2 C^{\frac{1-k}{2k}} = T_1 C^{\frac{k-1}{2k}} C^{\frac{1-k}{2k}} = T_1 C^{\frac{k-1}{2k}}$

$q_{in} = h_3 - h_7 = c_p(T_3 - T_7) = c_p(T_3)(1 - C^{\frac{1-k}{2k}})$

$q_{out} = h_6 - h_1 = c_p(T_6 - T_1) = c_p T_1(C^{\frac{k-1}{2k}} - 1)$

$\eta = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{c_p T_1(C^{\frac{k-1}{2k}} - 1)}{c_p T_3(1 - C^{\frac{1-k}{2k}})}$

$\eta = 1 - \frac{T_1}{T_3} \cdot C^{\frac{k-1}{k}}$

regen cycle with 2 stages has higher η than the standard regen cycle with the 1 stage of expansion