

T8 SOLUTIONS (WAITZ)1 of 2

a) $P_1 = 1 \times 10^6 \text{ Pa}$, $T_1 = 200 \text{ K}$, $C_1 = 50 \frac{\text{m}}{\text{s}}$ $\dot{m} = 100 \text{ kg/s}$


$P_2 = 5 \times 10^6 \text{ Pa}$ via A ϕ -s ADiab. PROCESS $\therefore pV^\gamma = \text{CONST.}$

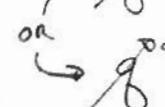
$C_2 = 50 \frac{\text{m}}{\text{s}}$

$\therefore q = 0$

$P_1 V_1 = RT_1 \Rightarrow V_1 = 0.052 \frac{\text{m}^3}{\text{kg}}$ ($R = 260 \text{ J/kg}\cdot\text{K}$)

$P_1 V_1^\gamma = P_2 V_2^\gamma$, $\gamma = \frac{C_p}{C_v} = 1.1 \Rightarrow V_2 = 0.012 \frac{\text{m}^3}{\text{kg}}$

SFEE  $-W_s = h_2 - h_1 + \frac{C_2^2}{2} - \frac{C_1^2}{2}$

or  $-W = u_2 - u_1 + \frac{C_2^2}{2} - \frac{C_1^2}{2}$

$W_f = R(T_2 - T_1) = W - W_s$

so

$W = -\left[C_v(T_2 - T_1) + \frac{C_2^2}{2} - \frac{C_1^2}{2} \right]$, $\frac{P_2 V_2}{R} = T_2 = 230.8 \text{ K}$

$W = -78.2 \frac{\text{kJ}}{\text{kg}}$

or

$\dot{W} = \dot{m} W = -7.8 \text{ MW}$

$W_f = 260(230.8 - 200) = 8 \frac{\text{kJ}}{\text{kg}}$

or

$\dot{W}_f = \dot{m} W_f = 0.8 \text{ MW}$

$W_s = -\left[C_p(T_2 - T_1) + \frac{C_2^2}{2} - \frac{C_1^2}{2} \right] = W - W_f$

$W_s = -86.2 \frac{\text{kJ}}{\text{kg}}$ or $\dot{W}_s = -8.62 \text{ MW}$

b) $C_2 = 50 \text{ m/s}$, $T_2 = 230.8 \text{ K}$, $p_2 = 5 \times 10^6 \text{ Pa}$ 2 of 2
 $C_3 = 100 \text{ m/s}$, $T_3 = ?$, $p_3 = 5 \times 10^6 \text{ Pa}$ $q_{in} = 1300 \text{ kJ/kg}$

$$q - \cancel{W_s} = C_p (T_3 - T_2) + \frac{C_3^2}{2} - \frac{C_2^2}{2} \quad (\text{NO SHAFT WORK BUT CAN STILL BE FLOW WORK})$$

$$1300 \times 10^3 = 2800 (T_3 - 230.8) + \frac{100^2}{2} - \frac{50^2}{2}$$

$$T_3 = 693.7, \quad v_3 = \frac{RT_3}{P_3} = \frac{260 (693.7)}{5 \times 10^6} = 0.036 \frac{\text{m}^3}{\text{kg}}$$

$$\boxed{W_s = 0} \quad W_f = R(T_3 - T_2)$$

$$\boxed{W_f = 260 (693.7 - 230.8) = 120 \frac{\text{kJ}}{\text{kg}}}$$

or

$$\dot{W}_f = 1.2 \text{ MW}$$

c) $\boxed{W_{s \text{ TURBINE}} = -W_{s \text{ PUMP}} = 86.2 \frac{\text{kJ}}{\text{kg}}}$ or $\dot{W}_s = 8.6 \text{ MW}$

$$\cancel{q} - W_s = C_p (T_4 - T_3) + \frac{C_4^2}{2} - \frac{C_3^2}{2}$$

$$-86.2 \times 10^3 = 2800 (T_4 - 693.7) + \frac{120^2}{2} - \frac{100^2}{2}$$

$$T_4 = 662 \text{ K}$$

$$W_f = R(T_4 - T_3) = 260 (662 - 693.7) = -8.2 \frac{\text{kJ}}{\text{kg}}$$

$$\boxed{W_f = -8.2 \frac{\text{kJ}}{\text{kg}} \quad \text{or} \quad \dot{W}_f = -0.82 \text{ MW}}$$