Problem 12.1

Senne Hemelaar
4573404

$T_1 = 303\ k$, $p_1 = 50\ kPa$, $v_1 = 80\ m/s$

$T_{t,1} = T_1 \left(1 + \frac{\gamma-1}{2} M_1^2\right)$

We know $\gamma = 7/5$. what is M_1?

$M_1 = \frac{v_1}{a_1}$, where $a_1 = \sqrt{\gamma R T_1} = 348.55\ m/s$

$M_1 = 0.229$

$T_{t,1} = 303 \left(1 + 0.2 \cdot 0.229^2\right) = 316.18\ k$

$T_{t,2} = T_{t,1} + \frac{q}{c_p}$

$\rightarrow \quad q = 40\ MJ/kg = 1 \cdot 10^6\ J$

$\rightarrow \quad c_p = \frac{\gamma R}{\gamma - 1} = 1004.67\ J/kg\,k$

$\boxed{T_{t,2} = 1311.53\ k}$

$\frac{T_{t,1}}{T_t^*} = \frac{2(1+\gamma)^2 M_1^2}{(1+\gamma M_1^2)^2}\left(1 + \frac{\gamma-1}{2} M_1^2\right) = 0.5258$

$T_t^* = 600.558\ k$

$\frac{T_{t,2}}{T_t^*} = \frac{2(1+\gamma)^2 M_2^2}{(1+\gamma M_2^2)^2}\left(1 + \frac{\gamma-1}{2} M_2^2\right) = 2.1838$

$\boxed{M_2 = 0.702}$

$\frac{p_1}{p^*} = \frac{2.4}{1 + 1.4 M_1^2} = 2.236$

$\frac{p_2}{p^*} = \frac{2.4}{1 + 1.4 M_2^2} = 1.4201$

$p_2 = \frac{p_2}{p^*} \cdot \frac{p^*}{p_1} \cdot p_1$

$\boxed{p_2 = 31.76\ kPa}$