AE 236 Quiz

1) $P_1 = 20$ bar

$T_1 = 373K$

$P_2 = 12$ bar

using

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

$$T_2 = \left(\frac{12}{20}\right)^{\frac{0.4}{1.4}} \times 373$$

$$\left[T_2 = 322.34K\right] \quad \{\text{Temp at final state}\}$$

using $P = \rho RT$

$$10^6 \times 12 = \rho\, 287 \times 322.34$$

$$\left[\rho = 129.7 kg/m^3\right] \quad \{\text{density at final state}\}$$

using $a = \sqrt{\gamma RT}$

$$\frac{a_1}{a_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{a_1}{a_2} = \sqrt{\frac{373}{322.34}}$$

$$\Rightarrow \left[\frac{a_1}{a_2} = 1.076\right] \quad \{\text{ratio of acoustic vel}$$

(2) $P_0 = 3$ bar

$T_0 = 300$ K

$V = 200$ m/s

using $V = M\sqrt{\gamma RT}$ — (1)

$$\frac{T_0}{T} = 1 + \left(\frac{\gamma-1}{2}\right) M^2 \quad \text{— (11)}$$

$$\Rightarrow \frac{T_0}{T} = 1 + \left(\frac{\gamma-1}{2}\right)\frac{V^2}{\gamma RT}$$

$$\Rightarrow \frac{300}{T} = 1 + \frac{0.2 \times 4 \times 10^4}{287 \times 1.4\ T}$$

$$\Rightarrow \frac{300}{T} - \frac{19.91}{T} = 1$$

$$\Rightarrow [T = 280.08\ K]$$

$$M = \frac{200}{\sqrt{1.4 \times 287 \times 280}} = 0.596$$

$$[M = 0.596]$$

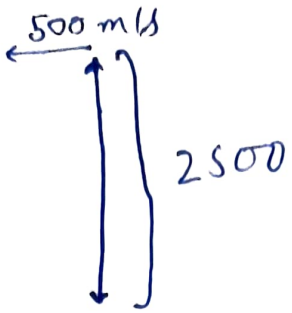
from isentropic table at M

$$\frac{P_0}{P} = 1.27550$$

$$\Rightarrow P = \frac{3}{1.2755}$$

$$\Rightarrow [P = 2.35\ \text{bar}]$$

(3)



$a = \sqrt{1.4 \times 287 \times (273+28)}$

$= 347 \text{ m/s}$

$V = 500 \text{ m/s}$

$M = \frac{500}{347} > 1$

[Time taken $= \frac{2500}{347} = 7.20 \text{ seconds}$]

(4)

leakage area $= 1 \text{ cm}^2 = 10^{-4} \text{ m}^2$

$P_{in} = 5 \text{ atm}$

$T = 20^\circ C$

using $P = \rho R T$

$\Rightarrow 10^6 \times \frac{5 \times 1.01325}{287 \times 293} = \rho$

$\Rightarrow \rho = 60.24 \text{ kg/m}^3$

$\frac{1}{2} \rho V^2 = P_1 - P_2$

$V_a = \sqrt{\frac{2 \times 4 \times 1.01 \times 10^6}{5 \times 1.01 \times 10^6} \times 287 \times 293}$

$V = 366 \text{ m/s}$

$$\text{mass} = \rho A V$$

$$= 60.24 \times 366 \text{ m/s} \times 10^{-4}$$

$$= 2.2 \text{ kg/s}$$