Problem Set 12 (PS 12) Due Tuesday April 18

Problems 5.12, 5.16, 5.17 1md 5.18 from the Anderson text

5.12

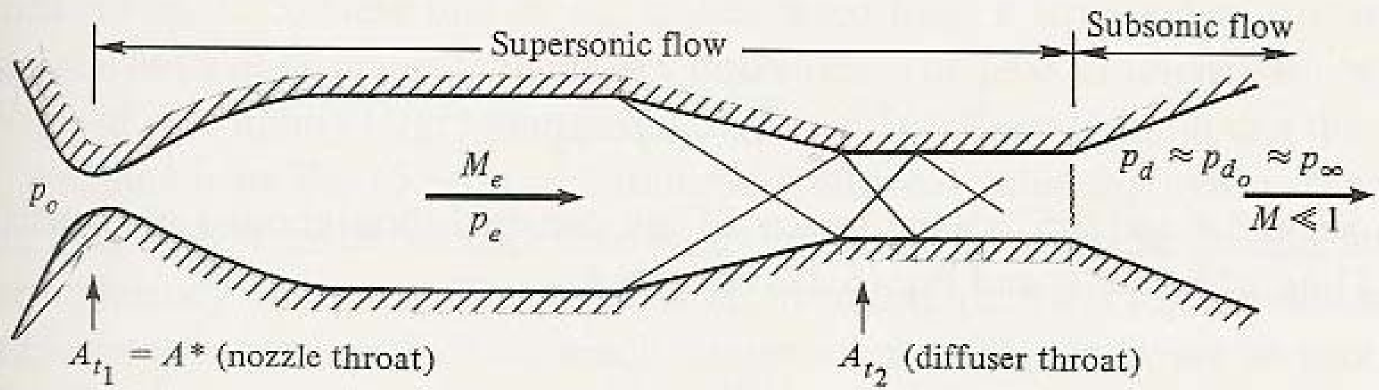


Figure 5.23 | Nozzle with a conventional supersonic diffuser.

Consider the tunnel to be completely isentropic,

isentropic @ $\frac{A_e}{A_{t1}} = 104.2; \quad M_{test} = 7.$

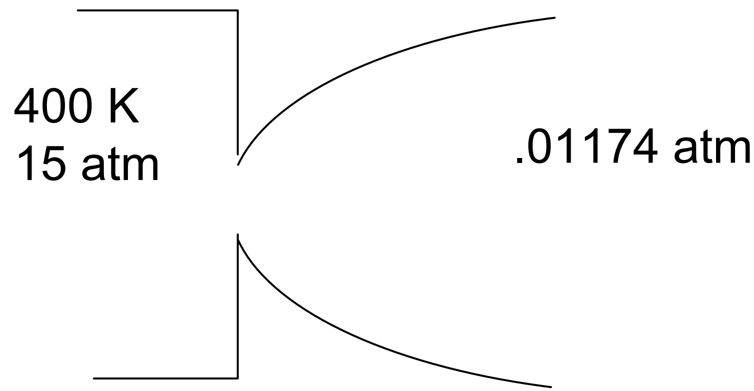
$$\left(\frac{A_{t2}}{A_{t1}}\right)_{min} = \frac{p_{Ot1}}{p_{Ot2}} \qquad (5.36)$$

for an normal shock at the end of the test section – the worst case

norma shock @ $M_1 = 7; \quad \frac{p_{02}}{p_{01}} = .01535$

$$\left(\frac{A_{t2}}{A_{t1}}\right)_{min} = \frac{1}{.01535} = 65.15$$

<u>5-16</u>



$$2H_2 + O_2 \Rightarrow 2H_2O$$

assume an ideal gas

assume isentropic

assume 15 atm is stagnation

$$\frac{p_O}{p} = \left(1 + \frac{\gamma - 1}{2} M^2\right)$$

$$\left(\left(\frac{p_O}{p}\right)^{\frac{\gamma-1}{\gamma}} - 1\right)\frac{2}{\gamma - 1} = M^2$$

$$\left(\left(\frac{15}{.01174}\right)^{.1803} - 1\right)\frac{2}{.22} = M^2$$

$$M = 4.9$$

5.17

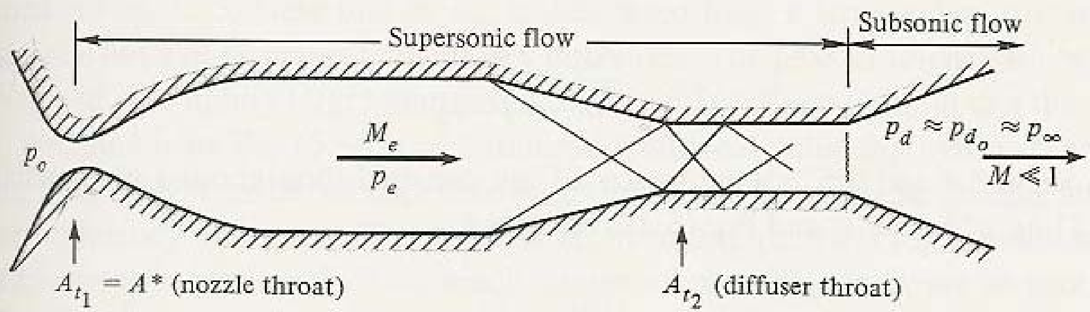


Figure 5.23 | Nozzle with a conventional supersonic diffuser.

a) isentropic @ $M = 3$; $\dfrac{A}{A^*} = 4.235 = \dfrac{A_e}{A_{t1}}$

b) normal shock at diffuser

normal shock @ $M_1 = 3$; $\dfrac{p_{O2}}{p_{O1}} = .3283$

equation (5.36) $\dfrac{A_{t2}}{A_{t1}} = \dfrac{p_{O1}}{p_{O2}} = \dfrac{1}{.3283} = 3.046$

isentropic @ $M = 3$, $\dfrac{p_O}{p} = 36.73$, $\dfrac{T_O}{T} = 2.740$

c) $p_O = 36.73 \times .1 = 3.673$ atm

d) $T_O = 2.74 \times 400 = 1096$ K

5.18

Wind tunnels 3000 K test sections of M=10 and M=20

$$\text{isentropic @ M} = 10; \quad \frac{T_O}{T} = 21$$

$$T_{test} = \frac{3000}{21} = 142.86$$

$$a_{test} = \sqrt{\gamma RT}$$

$$a_{test} = \sqrt{1.4 \times 287 \times 142.86}$$

$$= 239.6 \text{ m/sec}$$

$$V_{test} = M \times a$$

$$V_{test} = 10 \times 239.6 = 2396 \text{ m/sec}$$

$$\text{isentropic @ M} = 20; \quad \frac{T_O}{T} = 81$$

$$T_{test} = \frac{3000}{81} = 37.04$$

$$a_{test} = \sqrt{\gamma RT}$$

$$a_{test} = \sqrt{1.4 \times 287 \times 37.04}$$

$$= 122. \text{ m/sec}$$

$$V_{test} = M \times a$$

$$V_{test} = 10 \times 122. = 2440 \text{ m/sec}$$

Air would liquefy before reaching 37 K

High m is from low temperature not high velocity