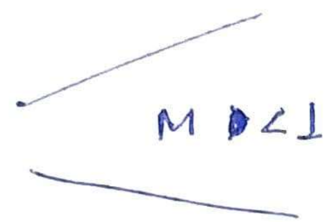
For. Diffuser.

$dv = -ve$. (always)

i) $M < 1$

$\frac{dA}{A} = (-ve)(-ve) \Rightarrow +ve$

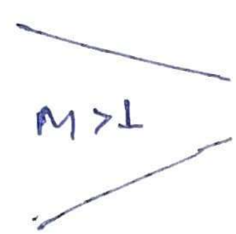
$\frac{dA}{A} = +ve$.



ii) $M > 1$,

$\frac{dA}{A} = (-ve)(+ve) \Rightarrow -ve$

$\frac{dA}{A} = -ve$



Critical flow condition in nozzle :-

For. nozzle.

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}.$$

$$V_1 << V_2.$$

$$h_1 = h_2 + \frac{V_2^2}{2}.$$

$$h_1 - h_2 = \frac{V_2^2}{2} \Rightarrow \qquad V_2 = \sqrt{2(h_1 - h_2)}$$

$$V_2 = \sqrt{2C_p(T_1 - T_2)}$$

$$V_2 = \sqrt{2 \times C_p \cdot T_1 \left(1 - \frac{T_2}{T_1}\right)}$$

$$V_2 = \sqrt{2 \times C_p \cdot T_1 \left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]} \qquad \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}.$$

$$\boxed{V_2 = \sqrt{2 \times C_p \cdot T_1 \left(1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right)}}$$

$$PV = mRT \Rightarrow \quad P = \rho RT. \quad \& \quad PV^\gamma = \text{cont}$$

$$\frac{P}{\rho^\gamma} = \text{cont} \Rightarrow \frac{P_1}{\rho_1^\gamma} = \frac{P_2}{\rho_2^\gamma}$$

$$\rho_1 = P_1 / RT_1 \qquad \rho_2 = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}} \times \rho_1$$

For. mass flow rate.

$$\dot{m} = \rho_2 A_2 V_2$$

$$\dot{m} = \rho_1 \times \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}} \times A_2 \times \sqrt{2 \times C_p \cdot T_1 \left(1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right)}$$

$$\dot{m} = \rho_1 \times \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}} \sqrt{2 \times C_p \cdot T_1 \left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

$$\frac{\dot{m}}{A_2} = \rho_1 \sqrt{2 \times C_p \cdot T_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{\gamma}} - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma+1}{\gamma}} \right]}$$

$$\frac{\gamma-1}{\gamma} + \frac{2}{\gamma} = \frac{\gamma-1}{\gamma}.$$

value of $\frac{P_2}{P_1}$ for max^m flowrate.

$$\frac{d(\dot{m}/A_2)}{d(P_2/P_1)} = 0.$$

other quantities except the ratio $\frac{P_2}{P_1}$ are constant.

$$\frac{2}{\gamma} \times \left(\frac{P_2}{P_1}\right)^{\frac{2}{\gamma}-1} - \frac{\gamma+1}{\gamma} \times \left(\frac{P_2}{P_1}\right)^{\frac{\gamma+1}{\gamma}-1} = 0$$

$$\frac{2}{\gamma}\left(\frac{P_2}{P_1}\right)^{\frac{2-\gamma}{\gamma}} = \frac{\gamma+1}{\gamma}\left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}.$$

$$\frac{2}{\gamma+1} = \frac{(P_2/P_1)^{\frac{1}{\gamma}}}{\left(\frac{P_2}{P_1}\right)^{\frac{2-\gamma}{\gamma}}}.$$

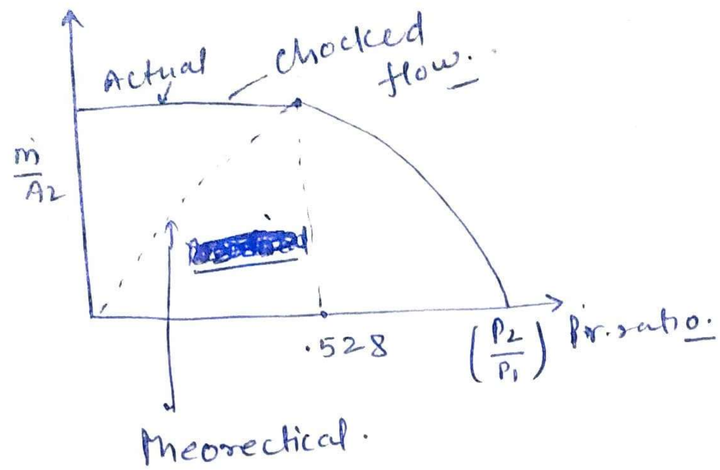
$$\frac{2}{\gamma+1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}.$$

$$\left(\frac{P_2}{P_1}\right) = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$

for $\gamma = 1.4$.

$$\boxed{\frac{P_2}{P_1} = 0.528}$$

critical pr. ratio.



Mass flow rate through convergent nozzle.

Fixed mass flow rate irrespective of pressure ratio is known as chocked flow.