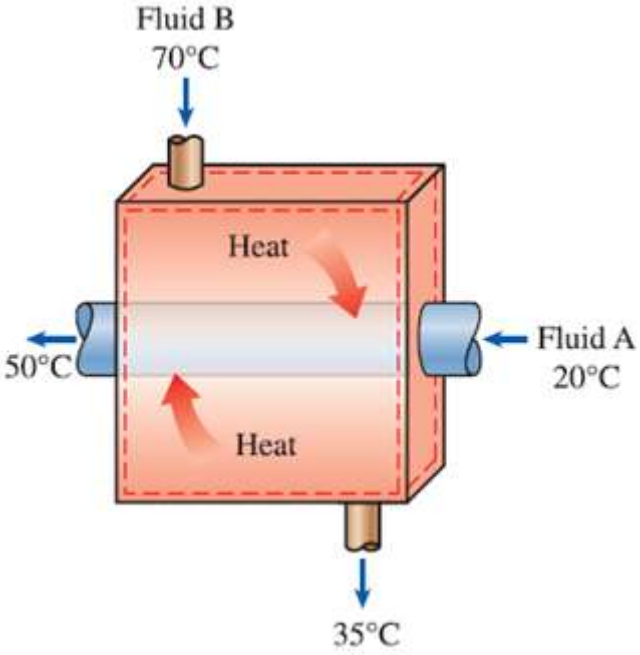
Energy balance via control volume-1
Mass Balance

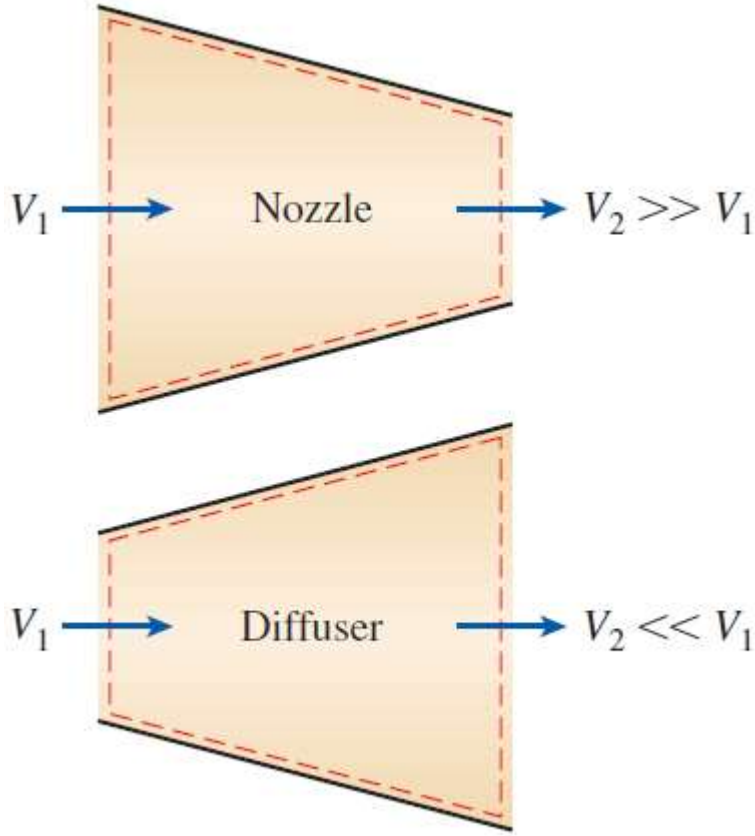
Raj Pala,
rpala@iitk.ac.in
Department of Chemical Engineering,
Associate faculty of the Materials Science Programme,
Indian Institute of Technology, Kanpur.

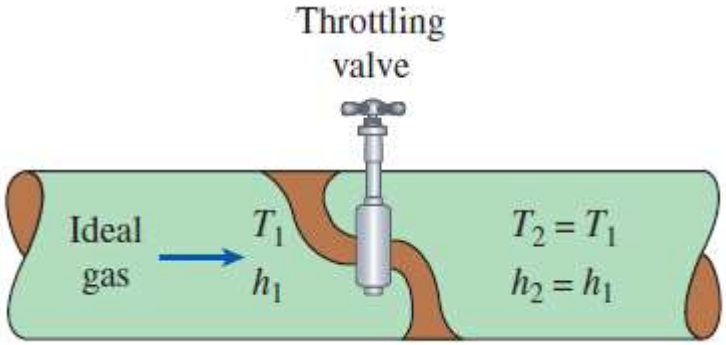
Energy balance for closed system

- 1st TD law: Conservation of energy; Q & W
- H, Specific heat
- Special scenarios & computational procedures

Engineering systems

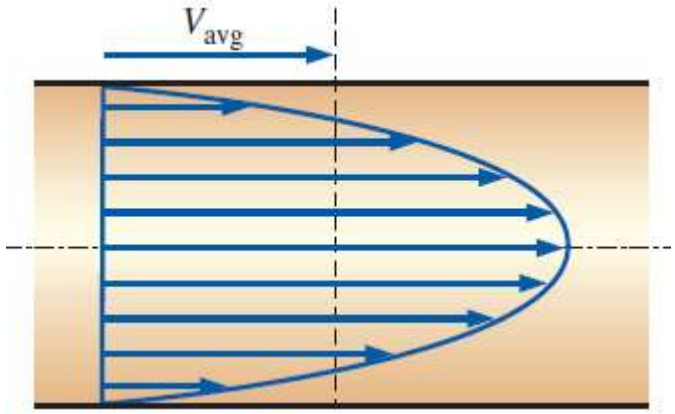


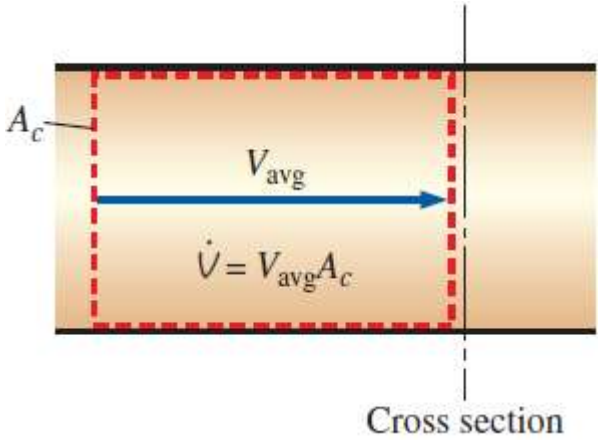




Figs: Cengel & Boles: TD

Elementary Mass Balances





$$V_{avg} = \frac{1}{A_c}\int_{A_c} V_n \, dA_c$$

$$\dot{V} = \int_{A_c} V_n \, dA_c = V_{avg}A_c = VA_c \qquad (m^3/s)$$

$$\delta\dot{m} = \rho V_n \, dA_c$$

$$\dot{m} = \int_{A_c} \delta\dot{m} = \int_{A_c} \rho V_n \, dA_c$$

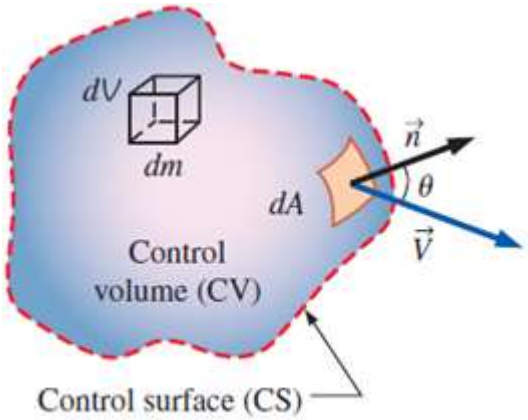
$$\dot{m} = \rho V_{avg} A_c \qquad (kg/s)$$

$$\dot{m} = \rho\dot{V} = \frac{\dot{V}}{v}$$ Mass flow rate

Figs: Cengel & Boles: TD

Mass Balances Over Control Volume

General conservation of mass: $\frac{d}{dt}\int_{CV} \rho\, dV + \int_{CS} \rho(\vec{V}\cdot\vec{n})\, dA = 0$



$$\frac{d}{dt}\int_{CV} \rho\, dV = \sum_{in} \dot{m} - \sum_{out} \dot{m} \quad \text{or} \quad \frac{dm_{CV}}{dt} = \sum_{in} \dot{m} - \sum_{out} \dot{m}$$

- Most fluids are incompressible: No variation in density

$$\sum_{in} \dot{V} = \sum_{out} \dot{V} \qquad (m^3/s)$$

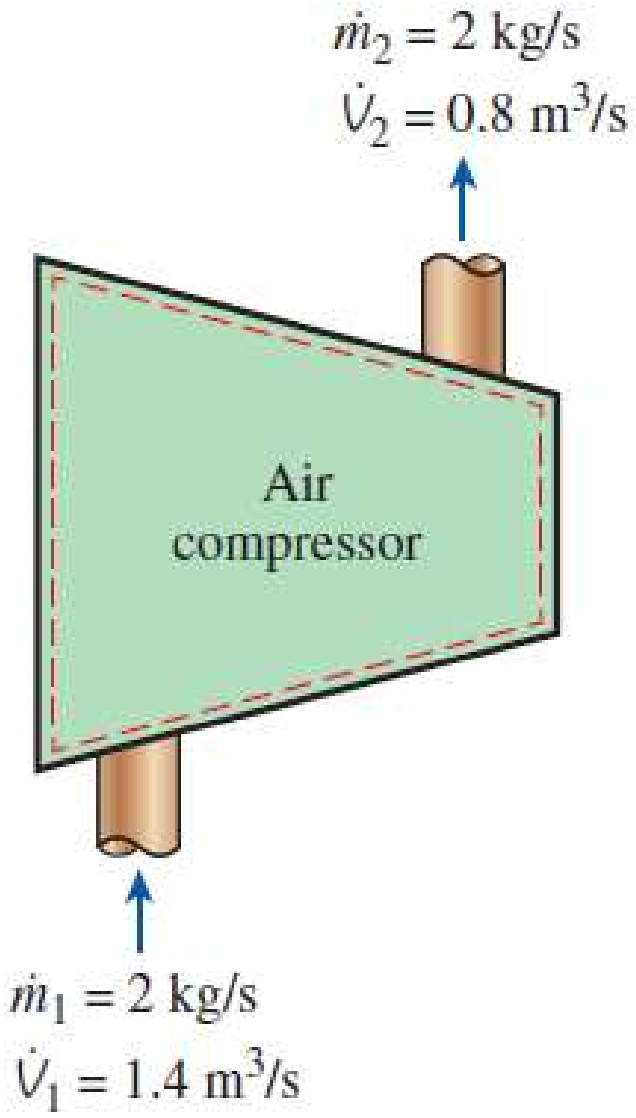
Steady, incompressible

$$\dot{V}_1 = \dot{V}_2 \rightarrow V_1 A_1 = V_2 A_2$$

Steady, incompressible flow (single stream)

Figs: Cengel & Boles: TD

No conservation of "volume"



Figs: Cengel & Boles: TD

What next?

- Mass Balance → Energy balance