The Lecture Contains:

Transport properties for gas mixture

Viscosity of gas mixture

Wassilijewa equation

$$\mu_{mix} = \sum_{i=1}^{N} \frac{X_i \mu_i}{\sum_{j=1}^{N} X_j A_{ij}}$$

$$A_{ij} = \frac{\left[1 + \left(\frac{\mu_i}{\mu_j}\right)^{0.5} \left(\frac{MW_i}{MW_j}\right)^{0.25}\right]}{\left[8(1 + \frac{MW_i}{MW_j})\right]^{0.5}}$$

Mason and Saxena modification

μ_i is the viscosity of the pure component

X_i is the mole fraction of the ith component

Thermal Conductivity of gas mixture

Wassilijewa equation

$$k_{mix} = \sum_{j=1}^{N} \frac{X_i k_i}{\sum_{j=1}^{N} X_j A_{ij}}$$

$$A_{ij} = \frac{\left[1 + \left(\frac{k_i}{k_j}\right)^{0.5} \left(\frac{MW_i}{MW_j}\right)^{0.25}\right]^2}{\left[8\left(1 + \frac{MW_i}{MW_j}\right)\right]^{0.5}}$$

Mason and Saxena modification

k_i is the thermal conductivity of the pure component

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Diffusion Coefficient of any component in a gas mixture

Wilke equation

$$D_i = \frac{1 - X_i}{\sum_{j=1\neq i}^{N} \frac{X_j}{D_{ij}}}$$

$$D_i = 262.8 \times 10^{-9} \frac{\sqrt{T^3 \frac{MW_i + MW_j}{2MW_i MW_j}}}{P\sigma_{ij}^2 \Omega_D}$$

Where,

σ_{ij} is the collision diameter in A^0

P is the pressure (Bar)

MW_i is the molecular weight of the components

Ω_D is the collision integral

$$T_{ij}^* = \sqrt{T_i^* T_j^*}$$

$$\Omega_D = \left(44.54 \times T_{ij}^{*-4.909} + 1.911 \times T_{ij}^{*\,1.575}\right)^{0.1}$$

$$T_i^* = \frac{T}{\varepsilon_o / k_B}$$

k_B =Boltzman's constant

ε_o =Intermolecular potential

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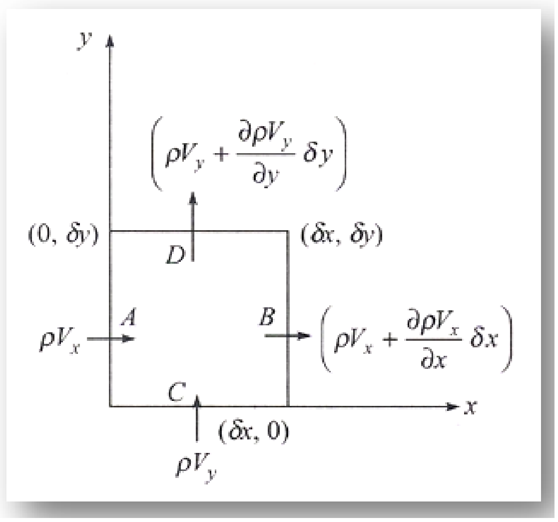
Mass conservation equation

Principle of mass conservation



$$\left\{\begin{array}{l}\text{Rate of mass accumulation}\\ \text{in fluid element}\end{array}\right\} = \left\{\begin{array}{l}\text{Rate of mass into}\\ \text{fluid element}\end{array}\right\} - \left\{\begin{array}{l}\text{Rate of mass out of}\\ \text{fluid element}\end{array}\right\} \qquad \text{------ (1)}$$

Rate of accumulation in fluid element = $\frac{\partial \rho}{\partial t}(\delta x \times \delta y \times 1)$ ------ (2)

Rate of mass in fluid element across face A = $\rho V_x(\delta y \times 1)$ ------ (3)

Rate of mass leaving fluid element across face B = $\left(\rho V_x + \frac{\partial(\rho V_x)}{\partial x}\delta x\right) \times (\delta y \times 1)$ ------ (4)

The net efflux in x-direction = $\frac{\partial(\rho V_x)}{\partial x} \times (\delta x \times \delta y)$ ------ (5)

The net efflux in y-direction = $\frac{\partial(\rho V_y)}{\partial y} \times (\delta x \times \delta y)$ ------ (6)

Substituting (2), (5) and (6) in (1)

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho V_x)}{\partial x} + \frac{\partial (\rho V_y)}{\partial y} = 0$$

Differential form of continuity equation

In vector notation,

$$\frac{\partial \rho}{\partial t} + \nabla . \rho V = 0$$

Where, ∇ is the gradient operator

$\nabla . (\rho V)$ is the divergence of ρV

For incompressible flow,

$$\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} = 0$$

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