Convection - Chapter - 2.

Basic Concepts

- Energy transfer in convection due to bulk motion of fluid particles through molecular conduction within fluid itself.

Convective heat transfer Coefficient

$m.$ $\rho = \frac{m}{v}$ $\rho . v$

$$Q = h A (T_s - T_\infty)$$

- The ratio of thermal conductivity of film to it's thickness is called as coeff of convective heat transfer or film conductance.

Continuity equation

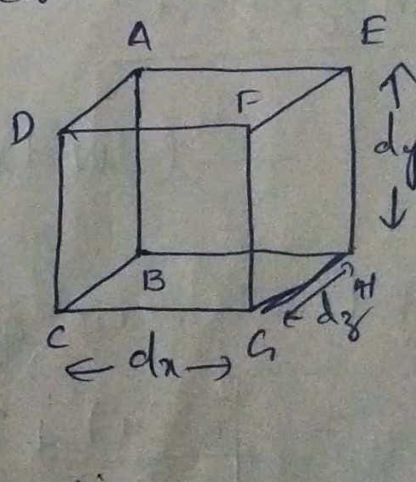
- Based on conservation of mass
  - Mass neither be created nor be destroyed

Total mass = Constant

Area x velo = volume

$\rho v = \rho A V$

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

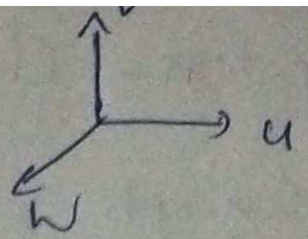


For an incompressible fluid,

ρ = constant

$$A_1 V_1 = A_2 V_2$$

- Mass of fluid per unit ~~volume~~ time entering through face ABCD (x direction)



$= \rho A V$

$= \rho(dy \cdot dz)\, u$

$= \rho u \cdot dy \cdot dz$

- Mass of fluid per unit time leaving the face

EFGH = $\left[\rho u \cdot dy\, dz + \frac{\partial}{\partial x}(\rho u\, dy\, dz)\, dx\right]$

Net mass of fluid remained in element (in x direct^n)

$= \rho u\, \cancel{dy dz} - [\rho u\, \cancel{dy dz}) + \frac{\partial}{\partial x}(\rho y\, dy\, dz)\, dx)$

$= -\frac{\partial}{\partial x}\rho u\, dx\, dy\, dz$ — ①

In y direction

$= \frac{-\partial}{\partial y}(\rho v\, dx\, dy\, dz)$ — ②

In z direct^n

$= \frac{-\partial}{\partial z}(\rho w \cdot dx \cdot dy\, dz)$ — ③

Total net mass of fluid remained in element/unit time

$= -\left[\frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z}\right)\, dx \cdot dy \cdot dz$ — ④

Rate of mass flow ↑ with time

$$= \frac{\partial}{\partial t}(\rho\, dx\, dy\, dz) \text{ --- } ⑥$$

Mass of fluid enter = mass of fluid leaving + rate of ↑ of mass wrt time

equating ④ in ⑤

$$= -\left[\frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z}\right] \cdot dx \cdot \cancel{dy} \cdot dz = \frac{\partial}{\partial t}(\rho \cdot dx \cdot \cancel{dy \cdot dz})$$

$$= \frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0$$

↑ 3D flow eqn for all type of fluid flow.

For a 2D flow, component, $w = 0$

For a steady flow, $\frac{\partial \rho}{\partial t} = 0$.

$$\frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0.$$

For incompressible fluid, $\rho =$ const.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \implies \text{3D flow}$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \implies \text{2D flow.}$$