After asking a question about the unknown thing,

Examination of it is a must by own reasoning,

As reasoning is the backbone of everything,

That is the sole objective of all our learning.

-Dr. D.P. Mishra

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The Lecture Contains:

- Introduction
- Laws of Transport Phenomenon

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Physics of Combustion

Introduction

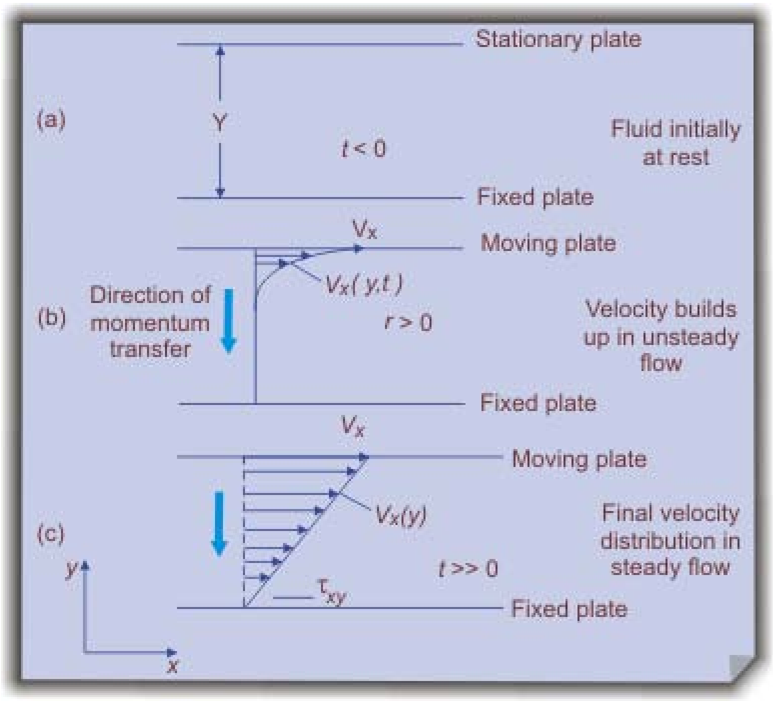
Module 3: Physics of Combustion

Lecture 12: Introduction

Laws of Transport Phenomenon

Newton's Law of Viscosity

- Two parallel plates- separated by 'Y'
- Lower plate is fixed
- At t< 0; system is at rest
- At t=0; upper plate is moved
- Velocity of plate: V_x



(Figure 12.1)

$$\tau_{yx} = \frac{F}{A} \propto \frac{V_x}{Y}$$

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Newton's Law of Viscosity can be expressed as,

$$\tau_{yx} = -\mu \frac{dV_x}{d_y}$$

Where, µ is dynamic viscosity (kg/ms)
dVx/dy is the shear strain rate
-ve sign: momentum flux in the direction of decreasing velocity

Viscosity for gases:

- Independent of pressure
- Temperature dependent

$$\mu \propto T^{0.7}$$

Viscosity for liquids:

- Decreases with increase in tempreature

Momentum transfer takes place from the region of higher velocity to lower velocity

Newtonian Fluids:

Gases and liquids which follow Newton's law of viscosity

Non - Newtonian Fluids:

Fluids which do not follow Newton's law of viscosity

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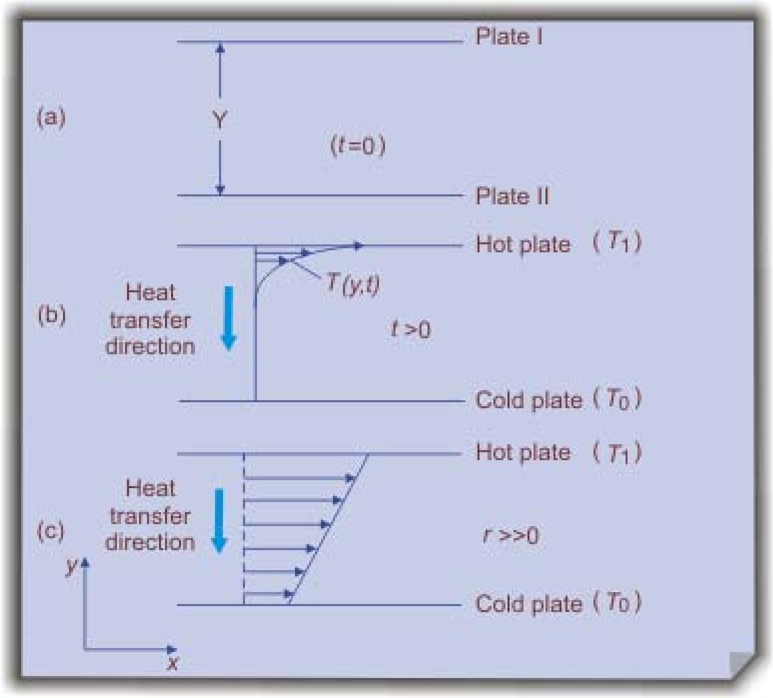
Fourier's Law of Heat Conduction

- Two parallel plates-separated by 'Y'
- Lower plate is fixed
- At t < 0; two plates are at the same temperature
- At t = 0; upper plate is suddenly heated ($T_1 > T_0$)
- Lower plate – Maintained at temperature T_0



(Figure 12.2)

$$\dot{q}'' = \frac{Q}{A} \propto \frac{T_1 - T_0}{Y}$$

$$q'' = -k\frac{dT}{d_y}$$

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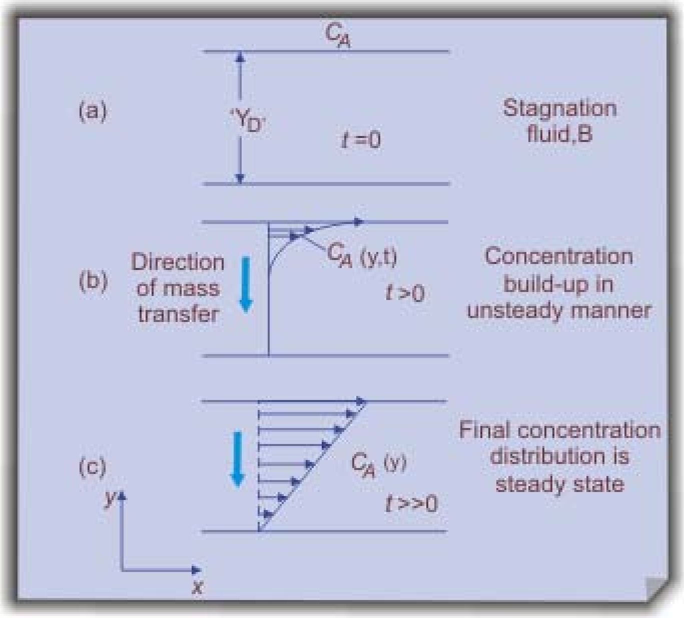
Fick's Law of Species Diffusion

- Two parallel plates-separated by 'Y'.
- Upper plate is maintained wet.
- Lower plate is kept dry (Dehydrating agent)
- Water vapour evaporates at upper plate
- Partial pressure of water vapour is maintained at saturated vapour pressure of water
- Thus concentration gradient exists between the two plates
- Mass flux-proportional to concentration, C_A inversely proportional to distance Y

$$m''_w \propto \frac{C_A}{Y_D}$$

Differential form of Fick's law

$$m''_A = -\rho D_{AB}\frac{dY_A}{d_y}$$



(Figure 12.3)

D_{AB} Binary diffusivity of species A through B

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