Unit -1/ 1-D steady state heat conduction with heat generation /Lesson plan No (LP-4/10)

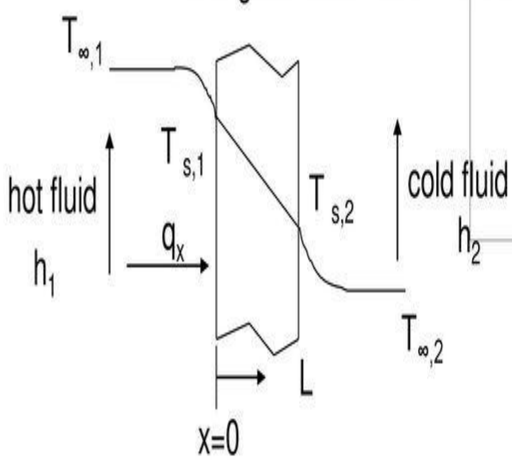
One-Dimensional Steady State Conduction

1. The Plane Wall

a) Temperature Distribution

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}+\frac{\dot{g}}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$$

- 1-D, steady state heat conduction through a slab with no heat generation and with constant thermal properties



Appropriate governing equation:

$$\frac{d}{dx}\left(k\frac{dT}{dx}\right)=0$$

$$\frac{d^2T}{dx^2}=0$$

- Find: 1. Temperature distribution (T=f(x)) along wall thickness
  2. Heat flux q_x'' through the wall
- Procedure:
  - Establish the coordinate system
  - Solve the heat equation using appropriate B.C.'s ⇒ T= f (x)
  - Estimate q" from Fourier's Law

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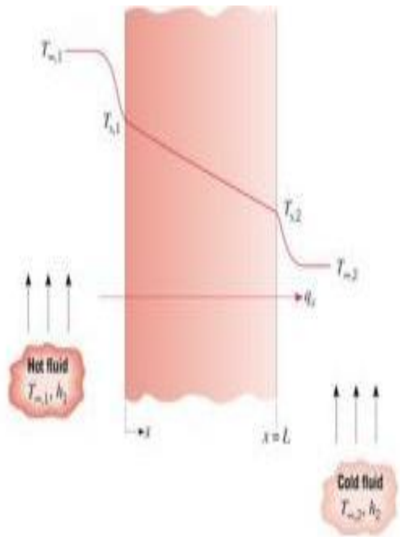

Governing Equation:

$$\frac{d^2T}{dx^2}=0$$

Dirichlet Boundary Conditions:

$$T(0)=T_{s,1}\ ;\quad T(L)=T_{s,2}$$

Solution: $T(x)=T_{s,1}+\left(T_{s,2}-T_{s,1}\right)\dfrac{x}{L}$ — temperature *is not* a function of *k*

Heat Flux: $q''_x=-k\dfrac{dT}{dx}=\dfrac{k}{L}\left(T_{s,1}-T_{s,2}\right)$

Heat Flow: $q_x=-kA\dfrac{dT}{dx}=\dfrac{kA}{L}\left(T_{s,1}-T_{s,2}\right)$

heat flux/flow *are* a function of *k*

Notes:

- *A* is the cross-sectional area of the wall *perpendicular* to the heat flow
- both heat flux and heat flow are uniform ➔ independent of position (x)
- temperature distribution is governed by boundary conditions and length of domain ➔ independent of thermal conductivity (k)