HEAT XFER

30 OCT 13
FAM

①

MACRO E-BAL:

$\Delta U + \Delta PV$

$$\Delta E_k + \Delta E_p + \Delta H = Q_{in} + W_{s,on}$$

changes w/ T
phase change
rxn

MEB $$\frac{\Delta P}{\rho} + \frac{\Delta v^2}{2\alpha} + g\Delta z + \bar{F} = W_{s,on}$$

☆ MEB = a macro E-bal specialized for circumstances common in mechanical systems.

In Heat Xfer
EQUIPMENT:

$$\cancelto{0}{\Delta E_k} + \cancelto{0}{\Delta E_p} + \Delta H = Q_{in} + \cancelto{0}{W_{s,in}}$$

Heat Exchanger
Condenser
Boiler
Reactor

$$\boxed{\Delta H = Q}$$

☆ This is the Macro E-bal specialized for circumstances common in heat xfer equipment.

$$\cancel{\Delta E_p} + \cancel{\Delta E_k} + \Delta H = Q_{in} + \cancel{W_{s,on}}$$

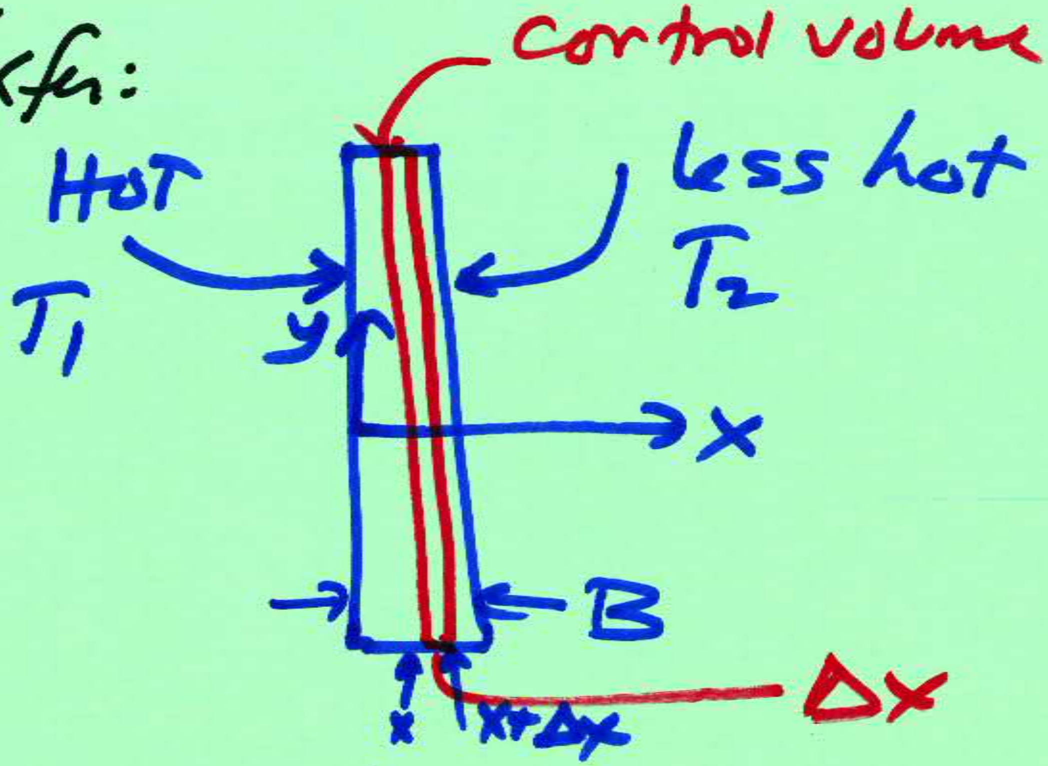
$$Q_{in} = \Delta H$$

$$= \sum_{outs} \dot{m}_i \hat{H}_i - \sum_{in} \dot{m}_j \hat{H}_j$$

$$Q_{in} = m_2 \hat{H}_2 + m_3 \hat{H}_3 - m_1 \hat{H}_1$$

☆ See Felder + Rousseau

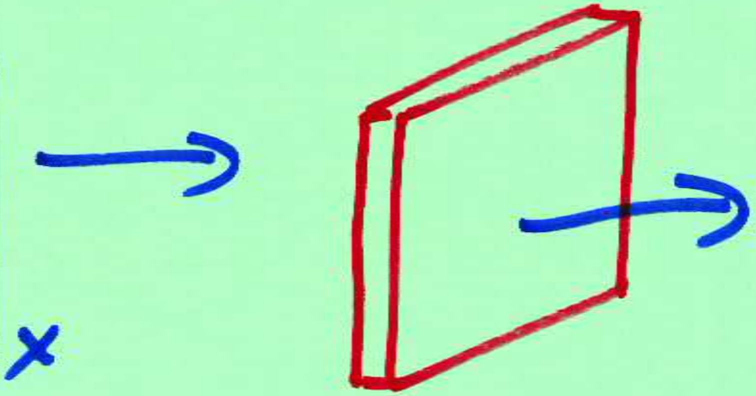
CV BAL
in Heat Xfr:



Height H
width W

choose control volume:

$$\underbrace{\left.\frac{q_x}{A}\right|_x}_{\text{heat flux}}$$



Steady state:
accumulation = 0
no current
no rxn

$$\left.\frac{q_x}{A}\right|_{x+\Delta X}$$

$$\left.\frac{q_x}{A}\right|_{x+\Delta x} = \left.\frac{q_x}{A}\right|_{x}$$

$$\lim_{\Delta x \to 0} \frac{\left.\frac{q_x}{A}\right|_{x+\Delta x} - \left.\frac{q_x}{A}\right|_{x}}{\Delta x} = 0$$

} the general
definition
of a derivative

$$\boxed{\frac{d}{dx}\left(\frac{q_x}{A}\right) = 0}$$

integrate:

$$\boxed{\frac{q_x}{A} = C_1}$$

(Flux is constant)

Fourier's LAW: $\frac{q_x}{A} = -k\frac{dT}{dx}$

$$C_1 = -k\frac{dT}{dx}$$

$$\frac{dT}{dx} = -\frac{C_1}{k}$$

Integrate: $\boxed{T = \left(-\frac{C_1}{k}\right)x + C_2}$

Boundary conditions:

$x = 0 \quad T = T_1$

$x = B \quad T = T_2$

Solve for c_1, c_2 (not shown; do the algebra)

$$\boxed{T = \left(\frac{T_2 - T_1}{B}\right) x + T_1}$$

What is the flux?

we know T(x)

$$\frac{q_x}{A} = -k \underbrace{\frac{dT}{dx}}$$

Fourier's LAW!

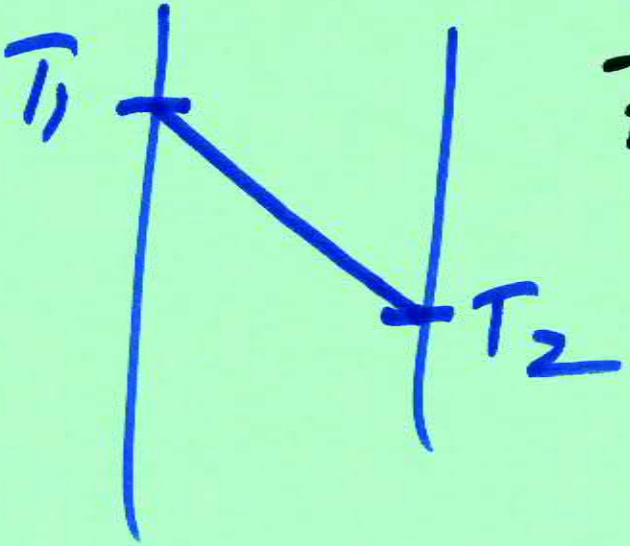
$$T = \left(\frac{T_2 - T_1}{B}\right) x + T_1$$

$$\frac{dT}{dx} = \left(\frac{T_2 - T_1}{B}\right)$$

$$\frac{q_x}{A} = -k \left(\frac{T_2 - T_1}{B}\right) \longleftarrow$$

FLUX depends on k (T-profile does not)

If I double the thermal conductivity k, how does the temp profile change?



★ (trick question: it does not change $T(x)$; it <u>does</u> change flux)