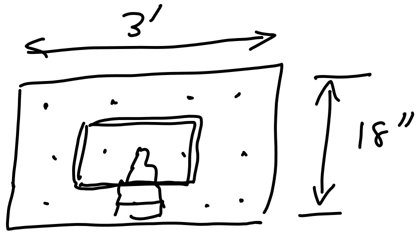
10/20/2010

THIS LECTURE

- FINISH THEORY OF EVAP. MODELLING
- EXAMPLES

- expts
- simulations



WINDOW OR GLASS BREAK CRITERION. } open for next 2 semesters

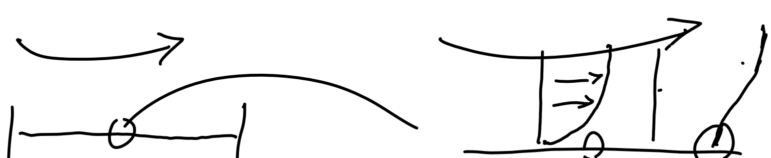
⇒ Review

LIQUIDS CLASSIFIED BY FLASHPOINT TEMPERATURE & FIREPOINT TEMP.

$0 <$	T_{FLASH}	$< 37°C$	CLASS I
$37 <$		$< 60°C$	II
$60°C <$			III

FOR IGNITION OF A FLAMMABLE POOL, THE

$$X_L < \frac{P_i}{P_{atm}} < X_u . \qquad X_F \equiv \frac{P_F}{P_{atm}}$$



neglect radiation

$$q''(y=0) = -k \left.\frac{\partial T}{\partial y}\right|_{y=0}$$

gas conductivity @ interface.

we would need $\frac{\partial T}{\partial y}$ from flow solution.

Fourier's law

$$q''|_{wall} = -k \left.\frac{\partial T}{\partial z}\right|_{wall} = h(T_w - T_\infty)$$ Newton's Law of cooling

$h \equiv$ heat transfer coefficient. We find h using correlations such as $Nu_L \equiv \frac{hL}{K} = C\, Re^m\, Pr^n$

$L \equiv$ charact length

$K \equiv$ thermal cond. gas mix

$m, n, C \equiv$ correlation specific coeff.

$Re \equiv$ Reynolds # $\equiv \frac{u_\infty L}{\nu}$ $\qquad$ $U_\infty \equiv$ flow speed

$\nu \equiv$ kinematic visc.

$Pr \equiv$ Prandtl # $\equiv \frac{\nu}{\alpha}$ $\qquad$ $\alpha \equiv$ thermal diffusivity

mass transfer problems $\qquad \underbrace{\dot{m}_i''}_{\text{mass flux.}} \equiv \frac{kg\ i}{s \cdot m^2}$

$$\underbrace{\dot{m}_i''}_{\substack{\text{diffusive}\\ \text{flux}}} = \underbrace{-\rho \mathcal{D} \frac{\partial Y_i}{\partial z}\Big|_0}_{\text{Fick's law}} = h_m\left(Y_{i,w} - Y_{i,\infty}\right)$$

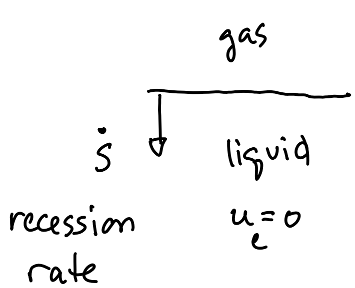
$\ast \quad \boxed{h_m = \frac{h}{c_p}}$

Lewis # $\equiv \frac{\alpha}{\mathcal{D}}$

Stanton # $= \frac{h}{\rho u_\infty c_p} \equiv \frac{h_m}{\rho u_\infty}$

low mass transfer limit.

$\updownarrow$ Clarification



in lab frame the problem is unsteady.

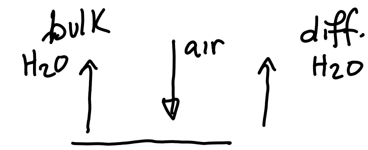
moving w/ the interface

$$0 \;\frac{\uparrow \rho_v u_v}{\uparrow \rho_\ell \dot{s}}$$

$\rho_v u_v = \rho_\ell \dot{s}$ $\qquad$ mass conservation

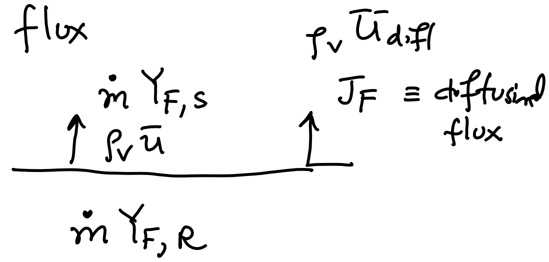
We discussed that the species velocity can be decomposed into the mass averaged velocity & a species velocity.

$$u_v = \bar{u} + \bar{U}_{Diff}$$



$$\rho_v u_v = \rho_v \bar{u} + \underbrace{\rho_v \bar{U}_{Diff}}_{\text{diffusional flux}}$$

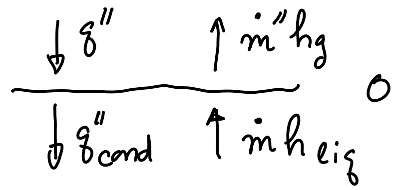
Just focusing on H_2O



for most of this chapter, we will neglect $\dot{m} Y_{F,s}$

we will use $J_F \approx h_m \Delta Y_F$

<u>surface energy balance</u>



steady ...

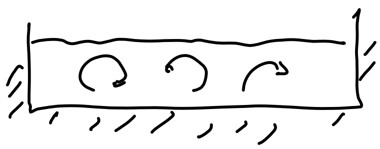
$$q'' + \dot{m}'' h_{liq} = q''_{cond} + \dot{m}'' h_g$$

$$q''_{incident} = \dot{m}''(h_g - h_{liq}) + q''_{cond}$$

The incident heat flux causes phase change & contributes to the in-depth heating of the pool.

$$q''_{inc} = \dot{m}'' \underbrace{h_{fg}}_{\text{Latent heat of vaporization.}} + q''_{cond}$$

sensible

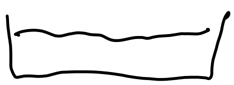


shallow, insulated pool, well mixed
then $q''_{cond} = 0$.

then $q''_{in} = \dot{m}'' h_{fg}$

$$\left.\begin{aligned} q''_{in} &= h(T_\infty - T_{surf}) \\ \dot{m}''_{out} &= h_m (Y_{surf} - Y_\infty) \end{aligned}\right\} \quad h(T_\infty - T_{surf}) = h_m h_{fg} (Y_{surf} - Y_\infty)$$

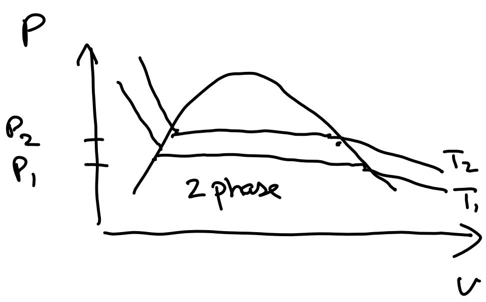
$T_\infty = 30°C$, $Y_{\infty, H_2O} = 0$, $h = 20 \frac{W}{m^2 K}$, $h_{fg} =$ " "



Do we have all info required to find $\dot{m}$?

No! It would be great to have T_{surf}!

$Y_{surf} = f(P_{surf})$ $\qquad$ $\underline{T_{surf} = f(P_{surf})}$



The surface is assumed to be a saturated mixture.

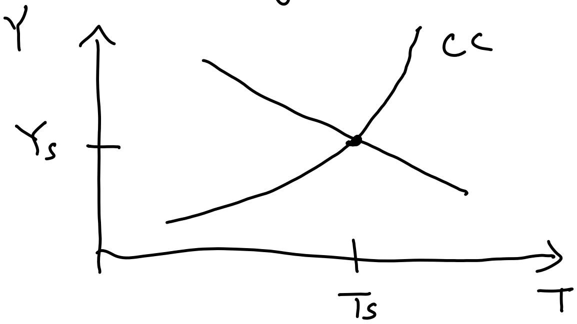
Thermodynamic relationships
Clausius - Clapyron

derived from Gibbs eqn. Equilibrium relationships.

near. end point $\qquad \dfrac{d \ln P}{dT} = \dfrac{h_{fg}}{RT^2}$ $\qquad$ integrate this.

$$\frac{P_{surf,i}}{P_0} = \exp\left[-\frac{h_{fg} M_i}{\bar{R}} \left(\frac{1}{T_s} - \frac{1}{T_{boil}} \right) \right]$$

essentially same a Y_i



2 eqns in 2 unknowns.