10/22/2010

THIS LECTURE

- Review of liquid evaporation
- Example Problems

(HW due on Weds)

Review

① assume T_{liq} specified

then $P_{vap,surf}$ specified

& $X_{vap,surf} = \frac{P_{vap}}{P_{TOTAL}}$

$X_L < X_{vap,surf} < X_u$

② assume $h, h_m, T_\infty, Y_{vap,\infty}$

then under some conditions shallow, insulated, well mixed

$$q'' = h(T_\infty - T_{surf}) = h_m(Y_{surf} - Y_\infty)$$

$$X = \frac{P_{vap}}{P_{TOTAL}} = \exp\left[-\frac{h_{fg}W}{\bar{R}}\left(\frac{1}{T_{surf}} - \frac{1}{T_b}\right)\right]$$

$$Y_i = \frac{n_i W_i}{\sum n_j W_j} = \frac{x_i W_i}{\overline{W}_{mix}}$$

3 eqns w/ 3 unknowns

T_{surf}, Y_{surf}, X_{surf}

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problem 6.5. CALCULATE VAPOR PRESS. OF LIQUIDS AT 0°C. USE CC & TABLE 6.1

a) n-octane   b) methanol   c) acetone

$\rightarrow$ $C_m H_n O_s H_p$ & CALCULATE W_i molecular weight

	n-octane	
T_b	398 K	
h_{fg}	0.3 kJ/g	

eqn 6.18. $$\frac{P}{P_{atm}} = \exp\left[\frac{h_{fg} W}{\bar{R}}\left(\frac{1}{T} - \frac{1}{T_b}\right)\right]$$

Problems 6.5 & 6.6 are similar.

Problem 6.13

a) compute the flashpoint temperature given

$T_b = 40 + 273$ K $P_{TOT} = 101$ kPa, $c_{p,l} = 2$, $\rho_l = 1330\ kg/m^3$

$X_L = 0.12$ ....

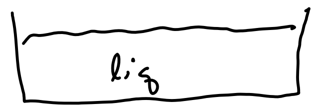
The procedure is to invert the C-C eqn for T_{surf} in terms of $X = \frac{P_{vap}}{P_{TOT}}$.

$$T = \left(\frac{1}{T_b} - \frac{\bar{R}\cdot \ln(X_L)}{h_{fg} W_1}\right)^{-1} \qquad T = 266\text{ K}$$

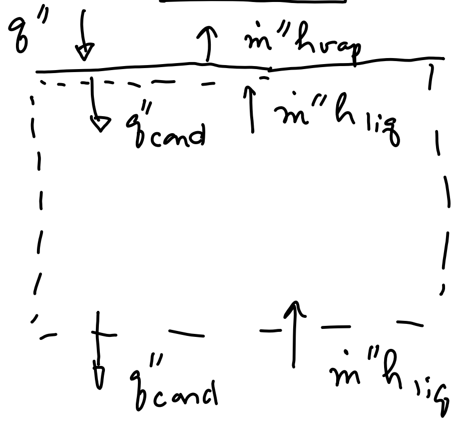
b) $T_\infty = 28°C$, $Y_\infty = 0$, $h = 10 \frac{W}{m^2 K}$, $h_m = \frac{h}{c_p}$

h_m ⇑ mass transfer coeff

c_p ↖ okay to use air c_p.



Assume <u>deep pool</u>. What does deep pool mean?



$$q''_{cond,\,top} + \dot{m}'' h_{liq,\,bot}$$

$$= q_{cond,\,bot} + \dot{m}'' h_{liq,\,top}$$

if $q''_{cond,\,bottom} = 0$

then

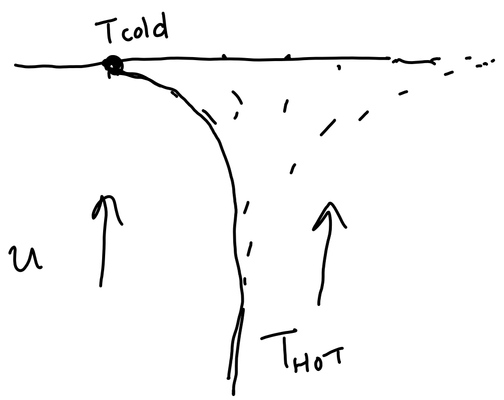
$$q''_{cond,\,top} = \dot{m}'' c_p (T_{surf} - T_{bottom})$$

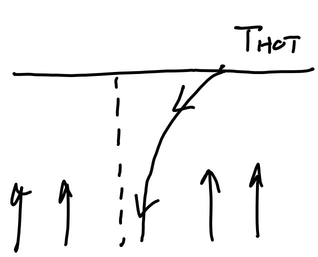
<u>surface balance</u>

$$q'' = \underbrace{\dot{m}''(h_{vap} - h_{liq})}_{\text{phase change process}} + \underbrace{q''_{cond}}_{\text{heat transfer into liquid}}$$

q'' external heat flux

⇑ $\dot{m}$ shallow pool we set this equal to zero.





$$q''_{external} = \dot{m}'' h_{fg} + \dot{m} c_p (T_{surf} - T_{bottom})$$

egn 6.34

$$= \dot{m}''[h_{fg} + \underbrace{c_p (T_{surf} - T_{bottom})}_{\text{correct for deep pools.}}]$$

$$h(T_\infty - T_{surf}) = \dot{m}''[\qquad\qquad\qquad]$$

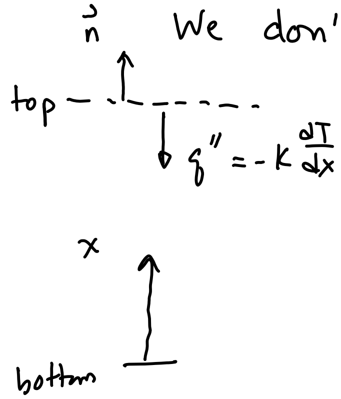
$$\uparrow$$

$$h_m[Y_{surf} - Y_\infty]$$

<u>Formally</u>

energy eqn applies in the liquid.

$$\underbrace{\rho u c_p \frac{dT}{dx}}_{\text{convection}} = \underbrace{k \frac{d^2T}{dx^2}}_{\text{conduction}}$$



We don't know ρu.

$$= \dot{m}'' \qquad \int_{bottom}^{top} \qquad\qquad dx$$

$$\dot{m}'' c_p (T_{Top} - T_{bottom}) = k\frac{dT}{dx}\Big|_{Top} - k\frac{dT}{dx}\Big|_{bottom}$$

$$= q_{cond,\,top} - \cancel{q_{cond,\,bottom}}$$

$= 0$

solution is available

$$\dot{m}'' c_p f = k \frac{df}{dx}$$

$$\ln f = \int \frac{\dot{m}''}{k} c_p \, dx$$

You get an exponential function.

$$\exp\left(\frac{\rho u c_p}{k} x\right) = \exp\left(\frac{u x}{\alpha}\right)$$

characteristic length.

α / u

* For a deep pool, the depth $H \gg \alpha/u$.