10/27/2010

THIS LECTURE

- MORE ON SOLID IGNITION
- HEAT TRANSFER IN SOLIDS

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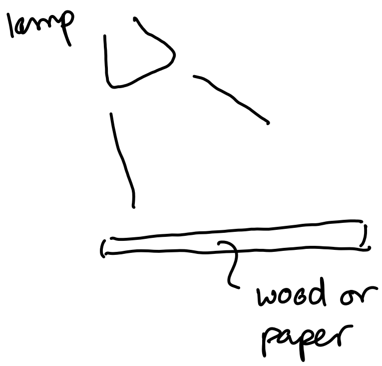
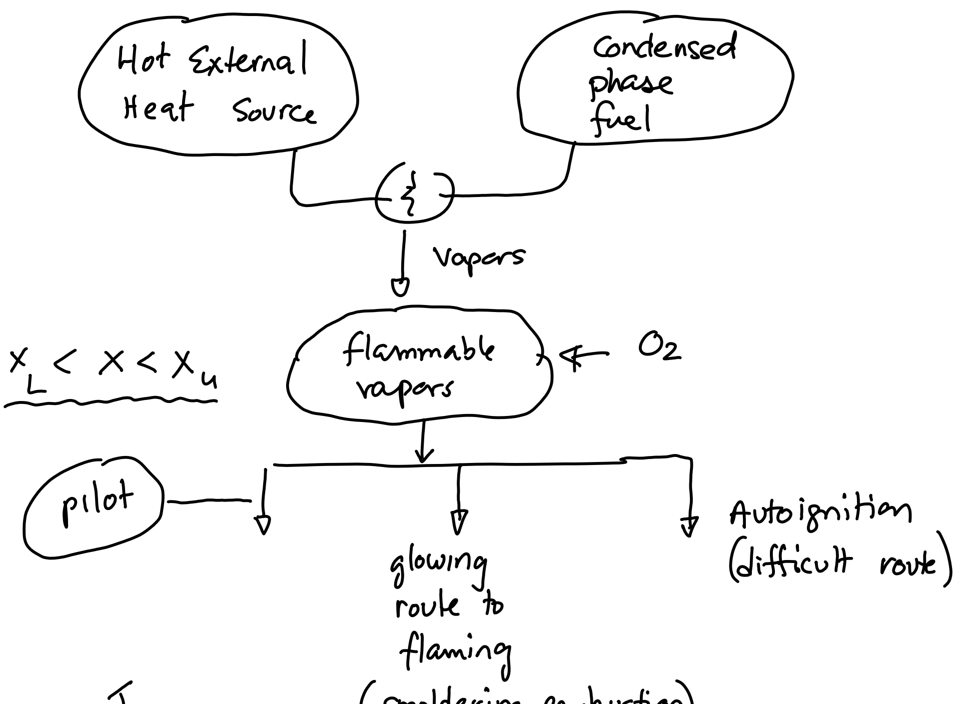
* LAST TIME: HEAT FLUXES ASSOCIATED w/ DIFFERENT THERMAL PROCESSES WERE DISCUSSED.



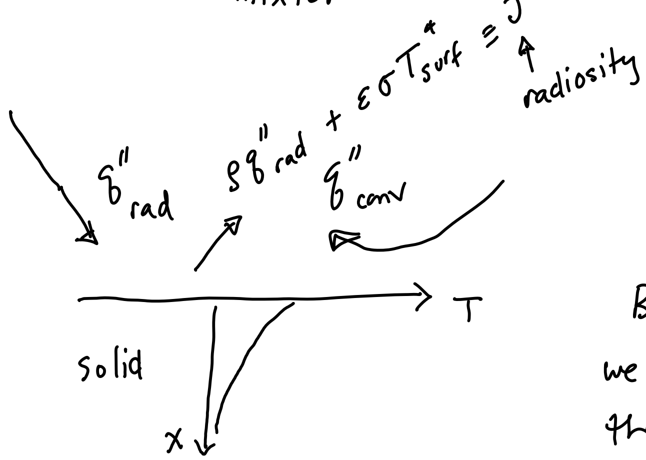
$x_L < x < x_u$

high temp source

overcome E_a in gas mixture

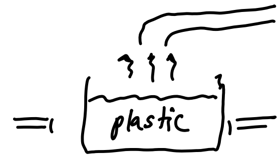


char begins to react & eventually transitions to flaming...



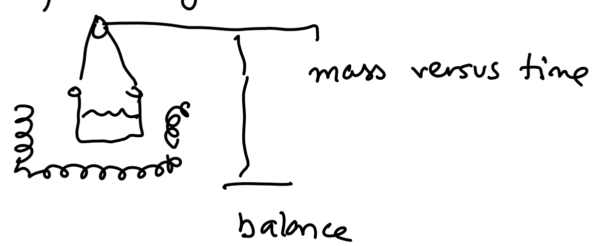
Before we can get any combustion we need to pyrolyze (thermally decompose) the solid.

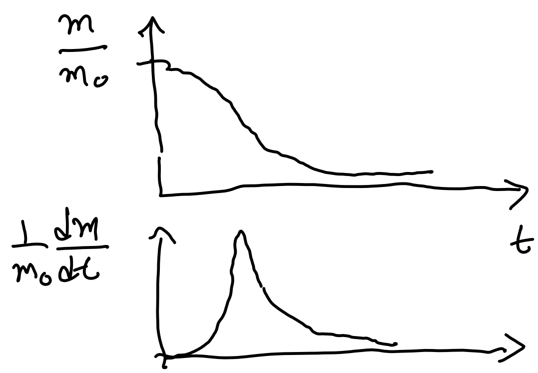
<u>Thermal Decomposition of Solids</u>



Very difficult research area...

Thermal gravimetric Analysis (expt technique) is a technique in which you put a pan w/ a small sample of solid material into an oven, and you measure the mass loss rate.





$$\frac{dm}{dt} = m\,A \exp\left(-E/_{RT}\right)$$

we fit an Arrhenius model to the mass loss data.

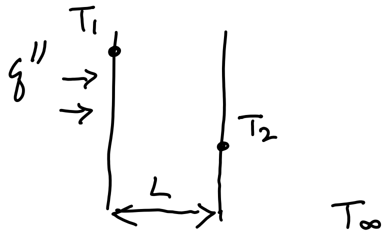
The textbook provides one approach to dealing with solid ignition. The simplest approach assumes that a surface ignition temperature is a reasonable marker for all the Kinetics that actually occur in the solid.

We will classify solid materials into 2 groups.

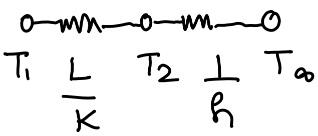
<u>Thermally Thin Samples</u> (lumped) Thermally Thick Samples ($\underset{\text{semi-}\infty}{?}$)

Analysis to establish if thick or thin....

1^{st} re-introduce the idea of the Biot number....



resistance goes to zero implies that potential difference goes to zero.



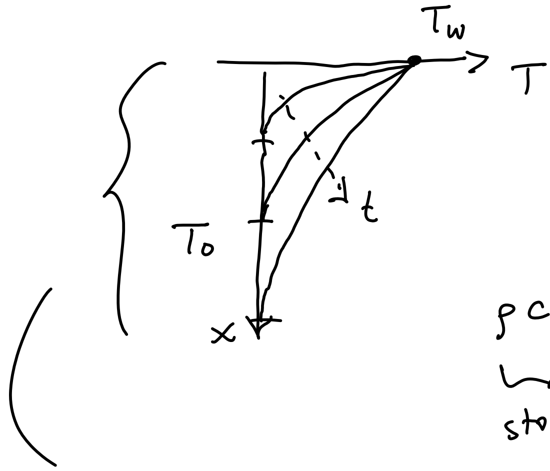
$$\underbrace{\frac{T_1 - T_2}{L/K} = \frac{T_2 - T_\infty}{1/h}}$$

This allows us to analyze relative temp. differences.

$$\frac{T_1 - T_2}{T_2 - T_\infty} = \underbrace{\frac{hL}{K}}_{Bi}$$

$Bi \to 0$ then $\frac{T_1 - T_2}{T_2 - T_\infty} \ll 1$ consider the system to be thermally lumped.

Thermally Thick



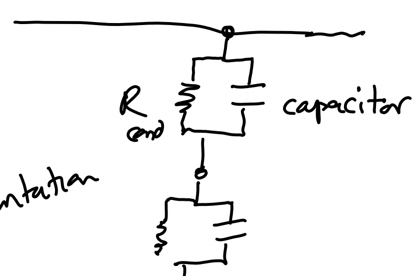
The energy eqn in the solid that describes this temp evolution looks like

$$\underbrace{\rho c \frac{\partial T}{\partial t}}_{\text{storage}} = \underbrace{K \frac{\partial^2 T}{\partial x^2}}_{\text{conduction}}$$

$$\frac{\partial T}{\partial t} = \frac{K}{\rho c} \frac{\partial^2 T}{\partial x^2}$$

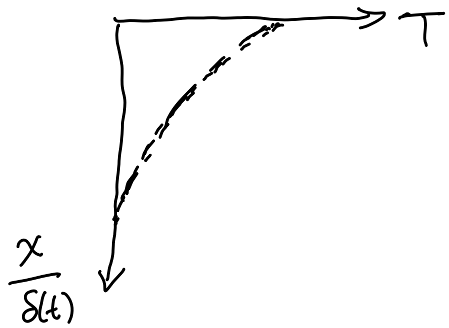
$\frac{K}{\rho c} \equiv \alpha \equiv$ thermal diffusivity

$\left[\frac{m^2}{s}\right]$ & tells us about speed



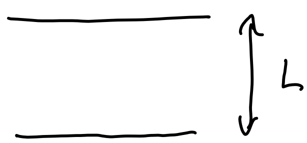
Not unique representation

of propagation.



all the temperature curves in the solid collapse on each other when the distance into the solid is normalized by a $\underbrace{\text{characteristic}}_{\text{diffusion distance}}$ length.

$$\delta(t) \equiv \sqrt{\alpha t}$$



$$\frac{\delta(t)}{L} = \frac{\sqrt{\alpha t}}{L} = \frac{\alpha t}{L^2} \equiv \text{Fourier \#}$$

$$Fo \equiv \frac{\text{diffusion distance}}{\text{true thickness}} = \frac{\delta^2}{L^2}$$

$$Fo \equiv \frac{t}{\tau_{Diff}} \Rightarrow \tau_{diff} \equiv \frac{L^2}{\alpha}$$