JQ.7.7.Setup

November 5, 2014

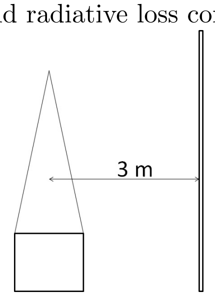
7.7 A flame radiates 40% of its energy. The fuel supply is 100 g/s and its heat of combustion is 30 kJ/g. A thin drapery is 3 m from the flame. Assume piloted ignition. When will the drapery ignite? The ambient temperature is 20 C and the heat transfer coefficient of the drapery is $10W/(m^2K)$. The drapery properties are:

$\rho = 40$, $c_p = 1400$, $T_{ig} = 350^oC$, $\delta = 0.002m$

You want to confirm that this is really a thin ignition problem. If it is thin, then the form is

$$t_{ig} = \frac{-\rho c_p \delta ln\left(1 - h_e(T_{ig} - T_e)/q_{rad}\right)}{h_e}$$

We see that we do not explicitly have the heat flux (q_e) from the flame to the fabric. That said, we can determine the heat flux from the problem statement. Given the fuel flow rate $\dot{m}_f$, heat of combustion Δh_c, and radiative loss contribution, χ, we can model the radiative heat flux.



The flame heat release rate is $\dot{Q} = \dot{m}_f \Delta h_c$. We assume that 40% of this power is lost radiatively. We denote the radiative loss fraction as $\chi = 0.4$. This suggests that the radiative heat transfer rate is $q_{rad} = \chi \dot{m}_f \Delta h_c$. Modeling the fire as a cylinder, we can assume that the radative power decays like $1/r$ from the fire. At the closest point the radiative heat flux to the fire is then:

$$q''_{rad} = q_{rad}/2\pi R L_f$$

This probem is not well specified. The flame length should have been given. Typical ceiling heights are about 3 m so we can use this as an estimate of the flame length.

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In [0]:
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