JQ.5.3.soln

October 23, 2014

5.3 Calculate the radius of a sherical pile of cotton gauze saturated with cottonseed oil to cause ignition in an environment with an air temperature Ta of 35 C and 100 C. Assume perfect heat transfer between the gauze surface and the air. The gauze was found to follow the Frank Kamenetskii ignition model.

The difference between the Frank-Kamenetski and Sedov ignition models is the inclusion of spatial gradients in the ignition model. The Sedov model assumes a vanishingly small Biot number or said differently a thermally lumped analysis. To analyze this problem, we again start with the Damkohler number and substitute the critical value of the Damkohler number. We look for the associated radial length scale.

$$\delta_c = \left(\frac{E}{RT_\infty}\right)\left(\frac{r_0^2(A\Delta h_c)exp(-E/RT_\infty)}{kT_\infty}\right)$$

$$r_0 = \delta_c^{0.5}\left(\frac{RT_\infty}{E}\right)^{0.5}\left(\frac{kT_\infty}{(A\Delta h_c)exp(-E/RT_\infty)}\right)^{0.5}$$

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In [29]: k=1.1*10**-4; ADhc=2.42*10**11; E=24.1*10**3; R=8.34/4.2; T_i=35.+273.; delta=3.32

In [30]: import math;

In [31]: ro= (delta**0.5)*((E/(R*T_i))**-.5)*(ADhc*(math.exp(-E/(R*T_i)))/(k*T_i))**-0.5;

In [32]: ro

Out[32]: 39.130059816326366
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For the case in which the temperature is 35^oC the radius would have to be 39 meters. for a higher temperature condition (i.e., $T_\infty = 100^oC$) we expect a much smaller radius.

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In [33]: T_i=100.+273.;

In [34]: ro= (delta**0.5)*((E/(R*T_i))**-.5)*(ADhc*(math.exp(-E/(R*T_i)))/(k*T_i))**-0.5;

In [35]: ro

Out[35]: 1.5295476451604164
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