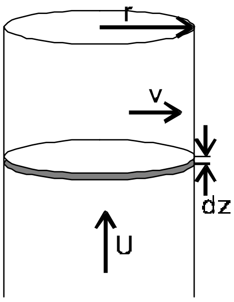

Please refer to Question 3, you will need to apply the same logic: the flow up a chimney is turbulent but we can assume that particles are deposited at some velocity within the laminar boundary layer. Considering a chimney of cylindrical symmetry the radial (v) and axial (U) velocities are

$$v = \frac{dr}{dt} \qquad \text{and} \qquad U = \frac{dz}{dt}$$

i) Using the concept of the fraction of particles removed (-dN/N) is equal to the fraction of the volume occupied by the differential ring dr within the slice dz, over which the capture takes place, as you did in the previous tutorial, derive an equation in which $N/N_0=f(v,r,L,Q)$, where Q is the axial air flow rate and L is the chimney height.

$$N=N_0 exp(-2BrvL/Q)$$

vi) The equation for mass of solids deposited per unit time is:

a: $\rho_s 2\pi r dz \frac{dr}{dt}(1-\varepsilon)$ b: $\rho_s 2\pi r dz \frac{dr}{dt}$ c: $\rho_s(1-\varepsilon)dr^3/dt$ d: $\frac{\rho_s(1-\varepsilon)}{2}drdtdzL/dt$

where ε is the deposit porosity, dr is the deposit thickness and ρ_s is the solid density.

vii) The mass of particles removed from the gas stream AT THE SAME TIME is:

a: $\pi r^2 \rho_s \frac{dz}{dt}$ b: $2\pi r^2 dz \frac{dN}{dt}$ c: $\pi r^2 \frac{dN}{dt}$ **d:** $\pi r^2 dz \frac{dN}{dt}$

viii) A mass balance in layer dz within the chimney provides the following result

$$-U\frac{dN}{dz} = \frac{dN}{dt}$$

and the differential form of your answer to (i) gives another equation for -dN/dz, combine these two equations and your answers to (vi) and (vii) to give an equation for the rate of increase in deposit thickness with time dr/dt=f[v, N (at h=0.5L), ρ_s, (1-ε)]:

$$\frac{dr}{dt} = vN/((1-\varepsilon)\rho_s)$$

derivation:

$$\frac{-\mathrm{d}N}{N} = \frac{2v}{rU}\mathrm{dz}$$ ... from (i)

hence,

$$\frac{-\mathrm{d}N}{\mathrm{dz}} = \frac{1}{U}\frac{\mathrm{d}N}{\mathrm{dt}}$$ ... from (viii)

Therefore,

$$\frac{\mathrm{d}N}{\mathrm{d}t} = \frac{2vN}{r}$$

Put the above into the answer to (vii) to give:

mass dust removed from gas stream = $\pi r^2 \delta z \frac{2vN}{r}$

mass deposited from (vi) = $\rho_s 2\pi r \delta z \frac{\mathrm{d}r}{\mathrm{d}t}(1-\varepsilon)$ NB these must be equal!!!

Combine the two above equations and cancel to give:

$$\frac{dr}{dt} = vN/((1-\varepsilon)\rho_s)$$