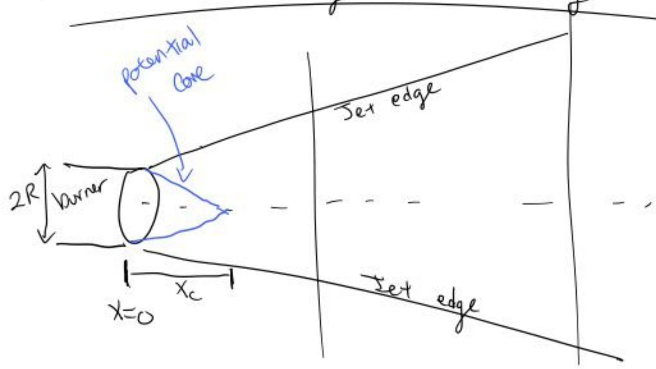
Laminar Diffusion Flames

Thursday, October 26, 2017 1:10 PM

1^{st}: non-reacting const.-density laminar jet



x=1

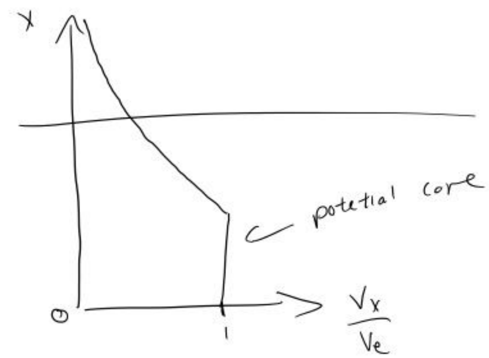
x=2

V_x @ nozzle $= V_o$

φ_i @ nozzle $= \varphi_{i,o}$

Momentum flow of the jet at any x, J = momentum flow issuing from the nozzle, J_e

$$2\pi \int_0^{\infty} \rho(r,x)\, V_x^2(r,x)\, r\, dr = \rho_e V_e^2 \pi R^2$$



Mass conservation (similar to momentum):

$$2\pi \int_0^{\infty} \rho(r,x)\, V_x(r,x)\, \Upsilon_{F}(r,x)\, r\, dr =$$

$\rho_e \; v_e \; '' \; K \quad Y_{F,e}$

Assumptions:

1) MW of jet & reservoir fluids are equal (+ I.G. law, const P, const T)
$\rightarrow$ uniform fluid ρ throughout flow field

2) molecular transport via Fick's law (binary diffusion)

3) momentum & diffusivity are const & equal. then Schmidt #
$Sc \equiv \nu / D_{AB}$ where $\nu = \frac{\mu}{\rho}$
is unity

4) only radial diffusion important

Mass conservation:

$$\frac{\partial v_x}{\partial x} + \frac{1}{r}\frac{\partial (v_r r)}{\partial r} = 0$$

Axial momentum conservation:

$$v_x \frac{\partial v_x}{\partial x} + v_r \frac{\partial v_x}{\partial r} = \nu \frac{1}{r}\frac{\partial}{\partial r}\left(r \frac{\partial v_x}{\partial r}\right)$$

$\partial x \qquad \partial r \qquad r \; \partial r \; \backslash \; \partial r /$

$$\nu = \mu / \rho$$

Species cons. for jet fluid (fuel):

$$v_x \frac{\partial Y_F}{\partial x} + v_r \frac{\partial Y_F}{\partial r} = D_{AB} \frac{1}{r}\frac{\partial}{\partial r}\left(r \frac{\partial Y_F}{\partial r}\right)$$

and $Y_F = 1 - Y_{ox}$