11-19-19 1
F. MORRISON
CM3110

Calculate Incipient Fluidization in a Fluidized Bed

(Algebraic details)

Net force down (w/ buoyancy correction)

$$\boxed{\begin{aligned} FORCE_{DOWN} &= (\Delta P A)_{DOWN} \\ &= \underbrace{(\rho_p - \rho)}_{\frac{mass}{vol}} \underbrace{(1-\varepsilon) A L}_{volume} g \end{aligned}}$$

FORCE UP:

$$FORCE = (\Delta P A)_{\text{from Ergun Eqn, low } Re_{DH}}$$

$$\underbrace{f_{DH}}_{\text{gives } \Delta P \rightarrow} = \frac{100/3}{Re_{DH}}$$

3

$$\boxed{f_{D_H} = \frac{\Delta P}{L} \frac{D_H \, \varepsilon^2}{2 \rho V_0^2}} \quad \text{EQN } 7.315$$

FORCE UP:

$$\Delta P A_{up} = \frac{L \, 2 \rho V_0^2 \, f_{D_H} \, A}{D_H \, \varepsilon^2}$$

$$= \frac{2 \rho L V_0^2 A}{D_H \, \varepsilon^2} \left(\frac{100/3}{Re_{D_H}} \right)$$

Eqn 7.317

$$= \frac{2 \cancel{\rho} L V_0^{\cancel{2}} A}{D_H \, \varepsilon^{\cancel{2}}} \frac{\frac{100}{3} \, 8 \, \mu}{\cancel{\rho} \cancel{V_0} D_H}$$

$$\boxed{(\Delta P A)_{up} = \frac{\frac{200}{3} A L V_0 \mu}{D_H^2 \, \varepsilon}}$$

(Force Up) = (Force Down)

$$\frac{\frac{200}{3}\cancel{\Delta} v_0 \mu \cancel{A}}{D_H^2\ \varepsilon} = \frac{(\rho_p-\rho)(1-\varepsilon)\cancel{A}\cancel{\Delta} g}{}$$

$$v_0 = \frac{(\rho_p-\rho)(1-\varepsilon)\, g\, D_H^2\, \varepsilon}{\mu\left(\frac{200}{3}\right)}$$

$$D_H = \frac{\cancel{4}^{2}\varepsilon D_p}{(1-\varepsilon)\cancel{6}_{3}}$$

eqns 7.304 & 7.311

$$v_0 = \frac{(\rho_p-\rho)\cancel{(1-\varepsilon)}\, g\, \varepsilon \left(\frac{4}{9}\right) \varepsilon^2 D_p^2}{\mu \frac{\cancel{200}^{50}}{\cancel{3}}\ (1-\varepsilon)^{\cancel{2}}}$$

$$\boxed{v_0 = \frac{(\rho_p-\rho)\, g\, \varepsilon^3 D_p^2}{150\mu\,(1-\varepsilon)}}$$

See lect. 13