ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

- PQI 3203 Fenômenos de Transporte I

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ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

Aula 15.5 – Equações para leitos

PQI 3203 Fenômenos de Transporte

Equações para perda de carga

1. D'Arcy
2. Ergun
3. Outras

D'Arcy – Permeabilidade (1830)

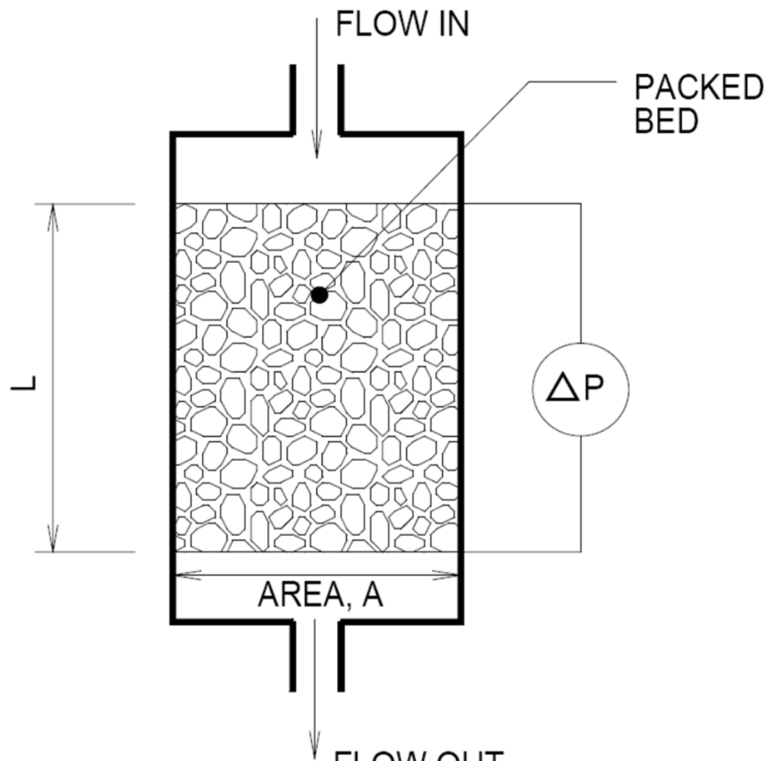


Figure 4-10. Typical Packed Bed.

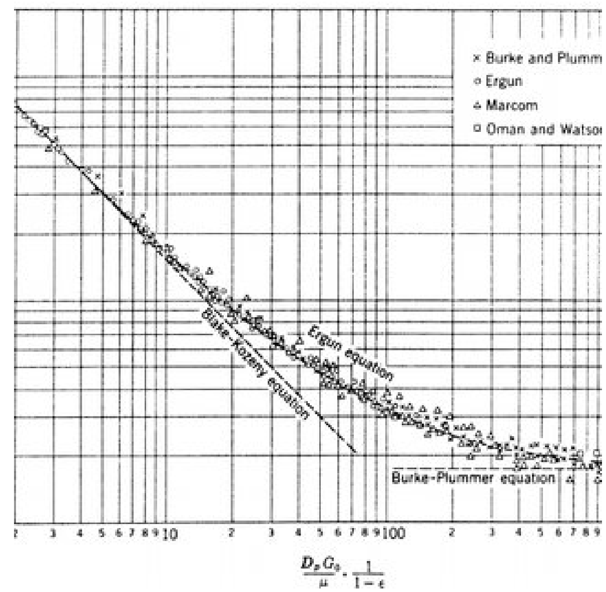
$$\frac{Q}{A} = \frac{k}{\mu}\left(\frac{P_0 - P_L}{L}\right)$$

Ergun

$$\frac{-\Delta\mathcal{P}}{L} = \frac{150\,\mu\,q\,(1-\varepsilon)^2}{(\psi D_P)^2\,\varepsilon^3} + \frac{1.75\,\rho\,q^2\,(1-\varepsilon)}{\psi D_P \varepsilon^3}$$

q = Q/ área do tubo, q é a velocidade dita superficial

Fluxo = G = ρ. q



Ergun

$$\frac{-\Delta\mathcal{P}}{L} = \frac{150\,\mu\,q\,(1-\varepsilon)^2}{(\psi D_P)^2\,\varepsilon^3} + \frac{1.75\,\rho\,q^2\,(1-\varepsilon)}{\psi D_P \varepsilon^3}$$

- Ou
- $\frac{-\Delta\mathcal{P}}{\rho\,q^2}\frac{\psi D_P}{L}\frac{\varepsilon^3}{(1-\varepsilon)} = \frac{150(1-\varepsilon)}{\rho\,q\,\psi D_P/\mu} + 1.75$

Ergun

- $\frac{-\Delta\mathcal{P}}{\rho\, q^2}\frac{\psi D_P}{L}\frac{\varepsilon^3}{(1-\varepsilon)} = \frac{150(1-\varepsilon)}{\rho\, q\ \psi D_P/_{\mu}} + 1.75$

- Onde: fator de fricção e Reynolds para a partícula

- $f_p = \frac{-\Delta\mathcal{P}}{\rho\, q^2}\frac{\psi D_P}{L}\frac{\varepsilon^3}{(1-\varepsilon)}$ $Re_{leito} = \frac{\rho\, q\ \psi D_P}{\mu\,(1-\varepsilon)}$ $f_p = \frac{150}{Re_{leito}} + 1.75$

Ergun

- Ergun

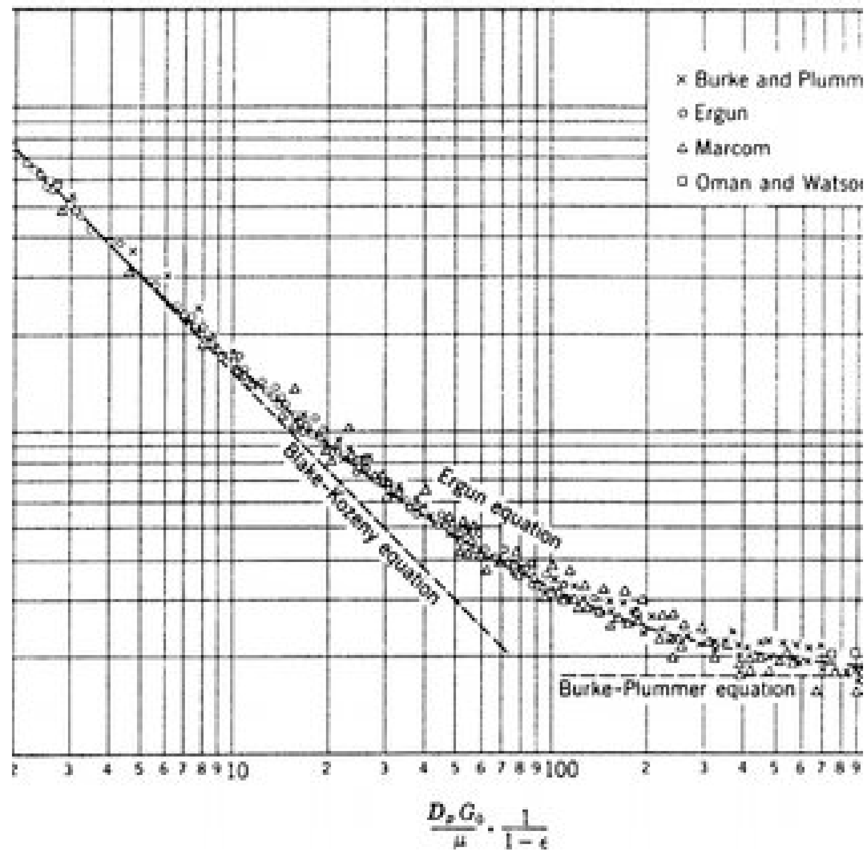
$$\frac{-\Delta\mathcal{P}}{L} = \frac{150\,\mu\,q\,(1-\varepsilon)^2}{(\psi D_P)^2\,\varepsilon^3} + \frac{1.75\,\rho\,q^2\,(1-\varepsilon)}{\psi D_P\,\varepsilon^3}$$

- Ou

- $$\frac{-\Delta\mathcal{P}}{\rho\,q^2}\frac{\psi D_P}{L}\frac{\varepsilon^3}{(1-\varepsilon)} = \frac{150(1-\varepsilon)}{\rho\,q\,\psi D_P/_{\mu}} + 1.75$$

- Onde

- $$f_p = \frac{-\Delta\mathcal{P}}{\rho\,q^2}\frac{\psi D_P}{L}\frac{\varepsilon^3}{(1-\varepsilon)} \qquad Re_{leito} = \frac{\rho\,q\,\psi D_P}{\mu\,(1-\varepsilon)} \qquad f_p = \frac{150}{Re_{leito}} + 1.75$$



Outras relações para perda de carga

- Tallmadge (1970) $0,1 < Re < 10^5$

$$f = \frac{150}{N_{Re}} + \frac{4,2}{{N_{Re}}^{1/6}}$$

Nemec e Levec (2005)

$$\frac{\Delta P}{L} = \frac{150}{\phi^{\frac{3}{2}}} \frac{(1-\varepsilon)^2}{\varepsilon^3} \frac{\mu . u}{(d_p \phi)^2} + \frac{1,75}{\phi^{\frac{4}{3}}} \frac{(1-\varepsilon)}{\varepsilon^3} \frac{\rho_f . u^2}{d_p . \phi}$$

- Gibilaro e Waldram (1985)

$$\frac{\Delta P}{L} = 17,3.\frac{\mu . u}{{d_p}^2}.\frac{(1-\varepsilon)}{\varepsilon^{4,8}} + 0,366.\frac{\rho_f . u^2}{d_p}.\frac{(1-\varepsilon)}{\varepsilon^{4,8}}$$

Conclusões

- Perda de carga em leito fixo
- Regimes laminar e turbulento
- Fluidodinâmica através de leito sólido

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