# Type III Pipe Flow Problems (D unknown)

Variables: $\Delta p = fn(Q, D, v, L, \epsilon)$

✓ ✓ ✓ ✓ ✓

$\Delta p = f \frac{L}{D} \frac{\rho V^2}{2}$ $\quad V = \frac{Q}{A}$

$\Delta p = f \frac{L}{D} \frac{\rho}{2} \left(\frac{Q}{A}\right)^2 = f \frac{L}{D} \frac{\rho}{2} \frac{Q^2}{\left(\frac{\pi}{4} D^2\right)^2}$

$\Delta p = f \frac{L}{D^5} \frac{\rho}{2} \frac{16}{\pi^2} Q^2$ ; Note: $Re = \frac{\rho V D}{\mu} = \frac{\rho \frac{Q}{A} D}{\mu}$

$= \frac{\rho Q D}{\frac{\pi}{4} D^2 \mu} = \frac{4 \rho Q}{\pi D \mu}$

~~$\Delta p = f \frac{L}{D^5} \frac{\rho}{2} \frac{16}{\pi^2} Q^2 \left(\frac{4\rho Q}{\pi D \mu}\right) \frac{\pi D \mu}{4 \rho Q}$~~ (Re)

~~$\Delta p = f \frac{L}{D^4} \frac{4}{\pi} Q Re_D$~~

$\left(D = \frac{4 \rho Q}{\pi Re \mu}\right)^5$

~~$\Delta p D^5 = f L \frac{8\rho}{\pi^2} Q^2$~~

~~$\Delta p \left(\frac{\pi Re \mu}{4 \rho Q}\right)^5 = f L \frac{8\rho}{\pi^2} Q^2$~~

$\frac{f}{D^5} = \Delta p \frac{\pi^2}{8 \rho L Q^2}$

$f \left[\frac{\pi Re \mu}{4 \rho Q}\right]^5 = \frac{\Delta p \pi^2}{8 \rho L Q^2}$

$f Re^5 = \frac{\Delta p \pi^2}{8 \rho L Q^2} \frac{(4 \rho Q)^5}{(\pi \mu)^5}$ $\Rightarrow$ Eq.(1)

$f^{1/5} Re = \left(\frac{\Delta p \pi^2}{8 \rho L Q^2}\right)^{1/5} \frac{4 \rho Q}{\pi \mu}$

$R_D \equiv$ roughness $\# = \dfrac{\epsilon/D}{Re_D}$

↑ can pick const. values of ~~$f$~~ $R_D$ & for $Re$ → allows you to find $f$

Note, can calculate $R_D$ without knowing diameter

Note: $Re = \dfrac{4\rho Q}{\pi D \mu}$

$$R_D = \frac{\epsilon/D}{4\rho Q/(\pi D\mu)} = \frac{\pi D \mu \epsilon}{4\rho Q}$$

← Eq. (2)

FIG. 3.5