Fluid Friction in Pipes

$$F\ (\text{frictional dissipation}) = \frac{8 U_m \mu L}{\rho a^2}$$

U_m: mean velocity

a: radius

friction factor f

$$f = \frac{\tau_w}{\frac{1}{2}\rho U_m^2}$$

laminar $Re < 2000$

transition $2000 < Re < 4000$

turbulent $Re > 4000$

for laminar

$$f = \frac{16}{Re}$$

for turbulent (Shacham equation)

$$f = \left\{ -1.737 \ln \left[0.269 \frac{\varepsilon}{D} - \frac{2.185}{Re} \ln \left(0.269 \frac{\varepsilon}{D} + \frac{14.5}{Re} \right) \right] \right\}^{-2}$$

ε: roughness (see table 3.2)

$$F = 2 * U_m^2 * f * \left(\frac{L}{D}\right)$$

$$F = \frac{32 f Q^2 L}{\pi^2 D^5}$$

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