Pipe Flow Friction Losses @model

The pressure drop in pipe flow due to fluid friction with pipe walls depends on mass flux density and friction factor distribution along the pipe.

(1) $$\left(\frac{dp}{dl} \right)_f = - \frac{j_m^2}{2d} \cdot \frac{f(l)}{\rho(l)}$$

where

l	pipe length
$j_m = \dot m / A = \rho_0 \, q_0 / A$	mass flux
$\dot m(l) = \dot m = \rm const$	mass flowrate
q_0	intake flowrate
ρ_0	intake fluid density
d	pipe diameter
$A = 0.25 \, \pi \, d^2$	pipe cross-section area
$f = f(\mathrm{Re}, \epsilon)$	Darcy friction factor
ϵ	inner pipe walls roughness
$\mathrm{Re} = \frac{j_m \, d}{\mu}$	Reynolds number
$\mu(T, p)$	dynamic viscosity as function of fluid temperature T and pressure p

The accurate calculations require solving of a self-consistent equation of Pressure Profile in Homogeneous Quasi-Isothermal Steady-State Pipe Flow @model.

There are few popular practical approximations based on assumption of constant friction factor and linear density-pressure equation of state.

Approximations

(2) $\Delta p(L) = - \frac{j_m^2}{\rho_0} \cdot \frac{f_0 \, L}{2 \, d} = - \frac{8}{\pi^2} \frac{\rho_0 \, q_0^2}{d^5} \, f_0 \, L$	$f(l) = f_0 = \rm const$ $\rho(l) = \rho_0 = \rm const$	Incompressible fluid
(3) $\Delta p(L) = - \frac{\rho_0}{c^*} \cdot \left[1 - \sqrt{1 - j_m^2 \cdot \frac{c^* \rho^*}{\rho_0^2} \cdot \frac{f_0 L}{d}} \right]$	$f(l) = f_0 = \rm const$ $\rho(l) = \rho^* \cdot (1 + c^* \, p)$ $c^* \, p \ll 1$	Slightly compressible fluid

(4) $\Delta p(L) = -p_0 \cdot \left[1 - \sqrt{1 - \frac{j_m^2}{\rho_0 \, p_0} \cdot \frac{f_0 \, L}{d}} \right]$	$f(l) = f_0 = \text{const}$ $\rho(l) = \frac{\rho_0}{p_0} \cdot p$	Ideal gas
(5) $\Delta p(L) = -\frac{j_m^2}{\rho_0} \cdot \frac{f_0}{2\,d} \cdot \frac{1 - \exp(-c^* \rho^* G \, L)}{c^* \rho^* G}$	$f(l) = f_0 = \text{const}$ $\rho(l) = \rho_0 \cdot \exp(c^* \rho^* G \, l)$	Gravity dominated fluid density distribution

See also

Physics / Fluid Dynamics / Pipe Flow Dynamics / Pipe Flow Simulation / Pressure Profile in Homogeneous Quasi-Isothermal Steady-State Pipe Flow @model

[Darcy friction factor] [Darcy friction factor @model] [Reynolds number in Pipe Flow]

[Fluid friction with pipeline walls][Darcy friction factor in water producing/injecting wells @model]