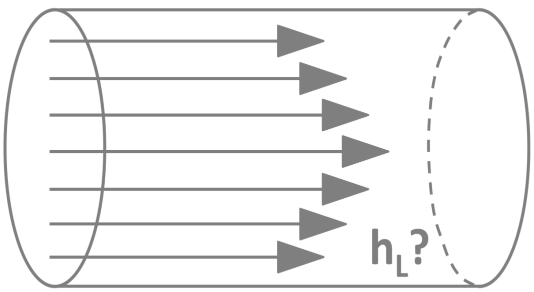
Head loss and Friction factor calculation

This application calculate Darcy-Weishbach friction factor and head loss of the friction for a straight pipe.



Laminar flow $f = \frac{64}{Rev}$

Turbulent flow $\frac{1}{\sqrt{f}} = -2 \cdot \log10\left(\frac{\frac{\epsilon}{D_{pipe}}}{3.7} + \frac{2.51}{Rey \cdot \sqrt{f}}\right)$

Head loss $h_L = f \cdot \frac{L}{D} \cdot \frac{v^2}{2 \cdot g}$

Design parameters

In this section, the type of fluid, pressure, temperature, and the geometrical parameters are defined for the calculation later.

Fluid properties

Fluid FluidName := "water"

Pressure at Design point $P_{dp} := 14.7\ psi$

Temperature at Design point $T_{dp\_F} := 60\ degF$

Pipe flow rate $Q := 0.600\ \frac{ft^3}{s}$

Geometrical parameters

Pipe diameter $D_{pipe} := 6\ inch$

Pipe roughness $\epsilon := 0.0005\ ft$

Pipe length $L := 100\ ft$

Others

Gravity $g := 32.17\ \frac{ft}{s^2}$

Fuild properties

Density and viscosity of fluid can be obtained with the fluid properties specified in the previous section.

Temperature at Design point in Kelvin

$T_{dp\_K} := \text{temperature\_conversion}\left(T_{dp\_F}, \text{"degF"}, \text{"K"}\right) = 288.706\ \mathrm{K}$

Note:
Function calls in ThermophysicalData package is better to be with temperature in Kelvin.
The unit of temperature can be converted with temperature_conversion() function defined in the Code region.

Density

$\rho := \text{ThermophysicalData:-Property}\left(\text{density}, \text{FluidName}, \text{pressure} = P_{dp}, \text{temperature} = T_{dp\_K}, \text{useunits}\right)$

$\rho = 62.367\ \frac{\mathrm{lb}}{\mathrm{ft}^3}$

Viscosity

$\mu := \text{ThermophysicalData:-Property}\left(\text{viscosity}, \text{FluidName}, \text{pressure} = P_{dp}, \text{temperature} = T_{dp\_K}, \text{useunits}\right)$

$\mu = 753.30 \times 10^{-6}\ \frac{\mathrm{lb}}{\mathrm{ft} \cdot \mathrm{s}}$

Darcy-Wiesbach friction factor and head loss

First, flow velocity and Reynolds number are obtained with the following calculation.

Flow velocity $$v := \frac{Q}{\pi \cdot \left(\frac{D_{pipe}}{2}\right)^2} = 3.056\ \frac{ft}{s}$$

Reynolds number $$Rey := \frac{D_{pipe} \cdot \rho \cdot v}{\mu} = 1.265 \times 10^5$$

The friction factor for both laminar and turbulent flow are defined as follow.

Laminar flow $$f_{laminar} := \frac{64}{Rey} = 5.059 \times 10^{-4}$$

Turbulent flow $$f_{turbulent} := \frac{1}{\sqrt{f}} = -2.0 \cdot \log10\left(\frac{\frac{\epsilon}{D_{pipe}}}{3.7} + \frac{2.51}{Rey \cdot \sqrt{f}}\right)$$

$$f_{turbulent\_sol} := solve\left(f_{turbulent}\right) = 0.022$$

Note:
Coolbrook-White equation for Darcy-Weisbach friction factor of Turbulent flow can be solved by using Lambert W function internally in Maple Flow.

Because the flow condition can be specified with Reynolds number, the friction factor is obtained.

Friction factor $$f_D := \begin{cases} f_{laminar} & Rey < 4000 \\ f_{turbulent\_sol} & Rey \geq 4000 \end{cases} = 0.022$$

Therefore, the head loss and pressure loss can be calculated with the following equations.

Head loss $$h_L := f_D \cdot \frac{L}{D_{pipe}} \cdot \frac{v^2}{2 \cdot g} = 630.46 \times 10^{-3}\ ft$$

Pressure loss $$dp := \rho \cdot g \cdot h_L = 0.273\ psi$$