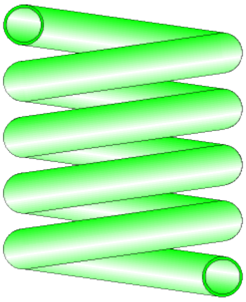
Helical Tube (Coil)
Circular Cross-Section
(MILLER)



Model description:

This model of component calculates the head loss (pressure drop) of a helical tube whose cross-section is circular and constant. In addition, the flow is assumed fully developed and stabilized upstream of the helical tube.

Model formulation:

Cross-section area (m^2):

$$A = \pi \cdot \frac{d_i^2}{4}$$

Mean velocity (m/s):

$$U = \frac{Q}{A}$$

Length measured along the axis (m):

$$L = n \cdot \sqrt{(\pi \cdot D)^2 + P^2}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Fluid volume (m^3):

$$V = A \cdot L$$

Fluid mass (kg):

$$M = V \cdot \rho$$

Reynolds number:

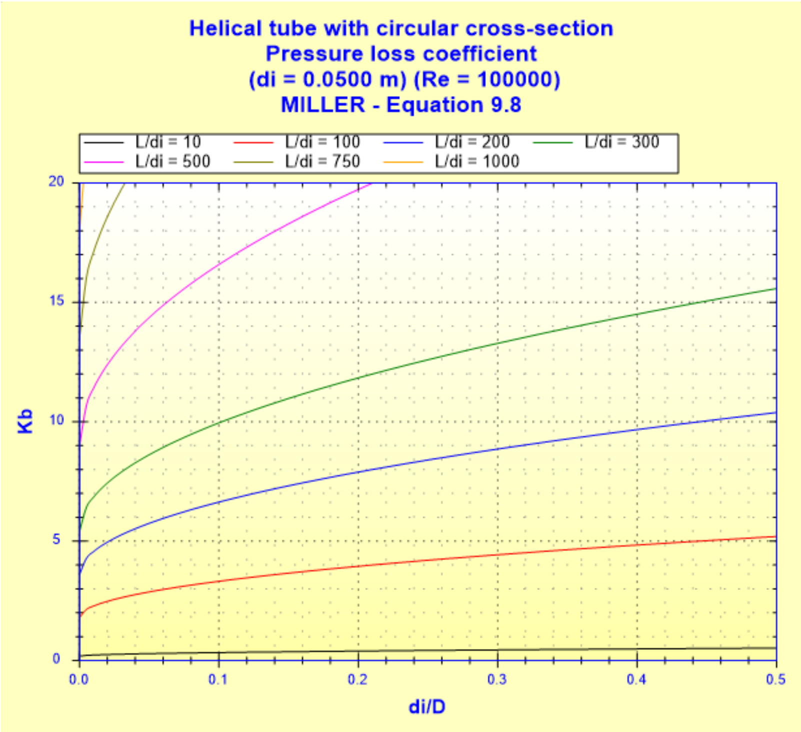
$$\boxed{\mathrm{Re} = \frac{U \cdot d_i}{\nu}}$$

Local resistance coefficient:

- $\mathrm{Re}_1 \geq 10^4$

$$\boxed{K_b = \left[0.32 \cdot \mathrm{Re}^{-0.25} + 0.048 \cdot \left(\frac{d_i}{D}\right)^{0.5}\right] \cdot \frac{L}{d_i}}$$

([1] Equation 9.8)



(with d_i=0.05 m and Re=10^5)

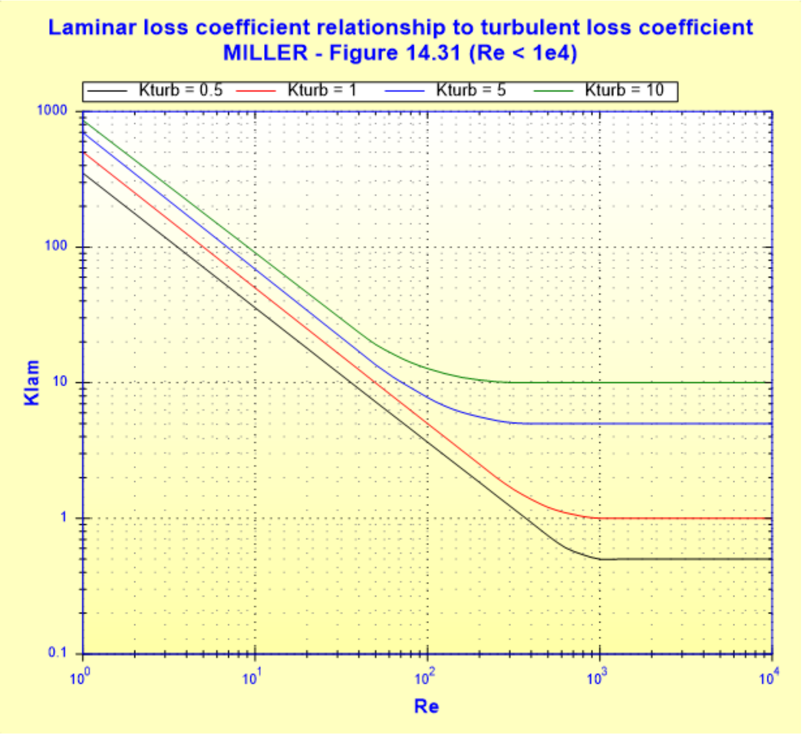
- $\mathrm{Re}_1 < 10^4$

$$\boxed{K_{lam} = f(K_{turb}, \mathrm{Re}_1)}$$

([1] figure 14.31)

where:

K_{turb} is the local resistance coefficient in turbulent regime (K_b for $\mathrm{Re} = 10^4$ - equation 9.8)



Total pressure loss coefficient (based on the mean velocity in the helical tube)

- turbulent flow ($\mathrm{Re} \geq 10^4$):

$$\boxed{K = K_b}$$

- laminar flow ($\mathrm{Re} < 10^4$):

$$\boxed{K = K_{lam}}$$

Total pressure loss (Pa):

$$\boxed{\Delta P = K \cdot \frac{\rho \cdot U^2}{2}}$$ ([1] equation 8.1b)

Total head loss of fluid (m):

$$\boxed{\Delta H = K \cdot \frac{U^2}{2 \cdot g}}$$ ([1] equation 8.1a)

Hydraulic power loss (W):

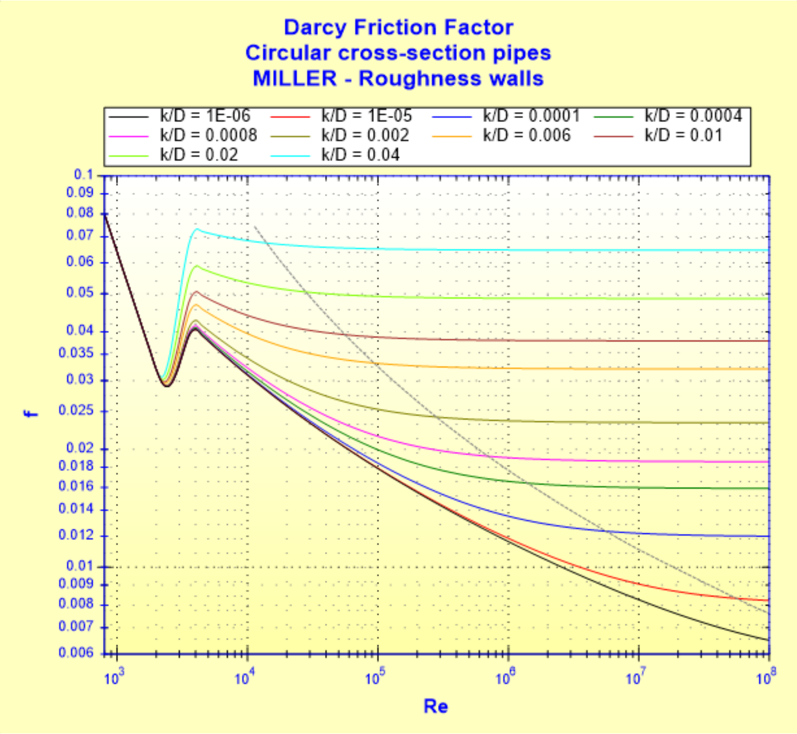
$$\boxed{Wh = \Delta P \cdot Q}$$

Darcy friction factor:

$$\boxed{f = f\left(\mathrm{Re}, \frac{k}{d_i}\right)}$$

with: k = 0 (hydraulically smooth tube)

See Straight Pipe - Circular Cross-Section and Roughness Walls (MILLER)



Straight length of equivalent pressure loss (m):

$$L_{eq} = K \cdot \frac{d_i}{f}$$

Symbols, Definitions, SI Units:

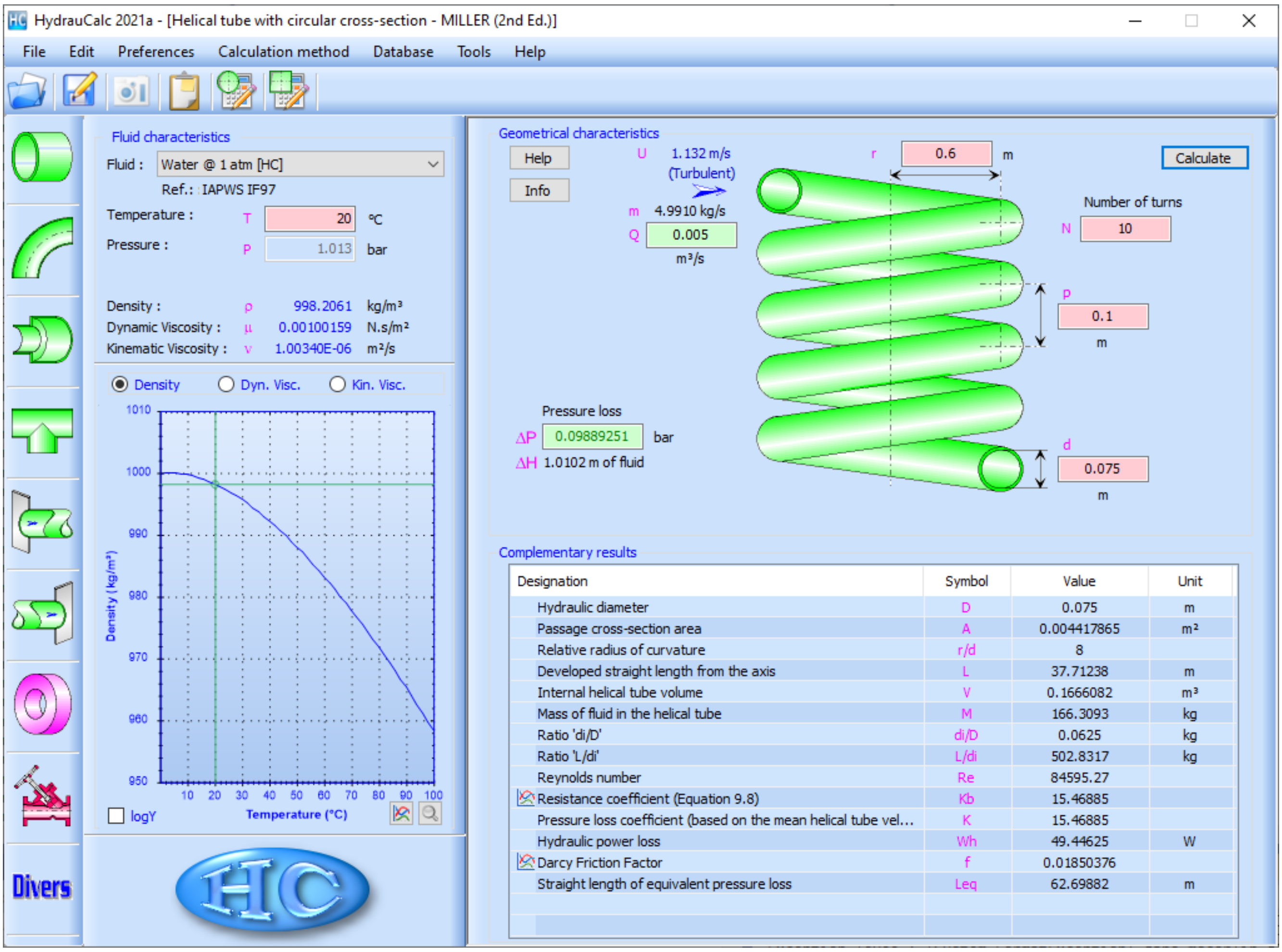
d_i	Helical tube internal diameter (m)
A	Cross-section area (m^2)
Q	Volume flow rate (m^3/s)
U	Mean velocity (m/s)
P	Pitch of the helical tube (m)
n	Number of turns constituting the helical tube ()
L	Length measured along the axis (m)
D	Diameter of curvature of the helical tube (m)
G	Mass flow rate (kg/s)
V	Fluid volume (m^3)
M	Fluid mass (kg)
Re	Reynolds number ()
K_b	Local resistance coefficient for $Re = 10^4$ ()
K_{lam}	Local resistance coefficient for $Re < 10^4$ ()
K	Total pressure loss coefficient (based on the mean velocity in the helical tube) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
f	Darcy friction factor ()
L_{eq}	Straight length of equivalent pressure loss (m)
ρ	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)

g Gravitational acceleration (m/s^2)

Validity range:

- any flow regime: laminar and turbulent
  note: for laminar flow regime ($Re < 10^4$), the pressure loss coefficient "K_{lam}" is estimated
- hydraulically smooth flow
- stabilized flow upstream helical tube

Example of application:



References:

[1] Internal Flow System, Second Edition, D.S. Miller