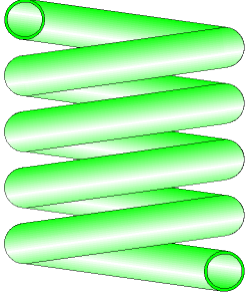




Helical Tube (Coil) Circular Cross-Section (MILLER)



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 (m²):

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

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 (m³):

$$V = A \cdot L$$

Fluid mass (kg):

$$M = V \cdot \rho$$

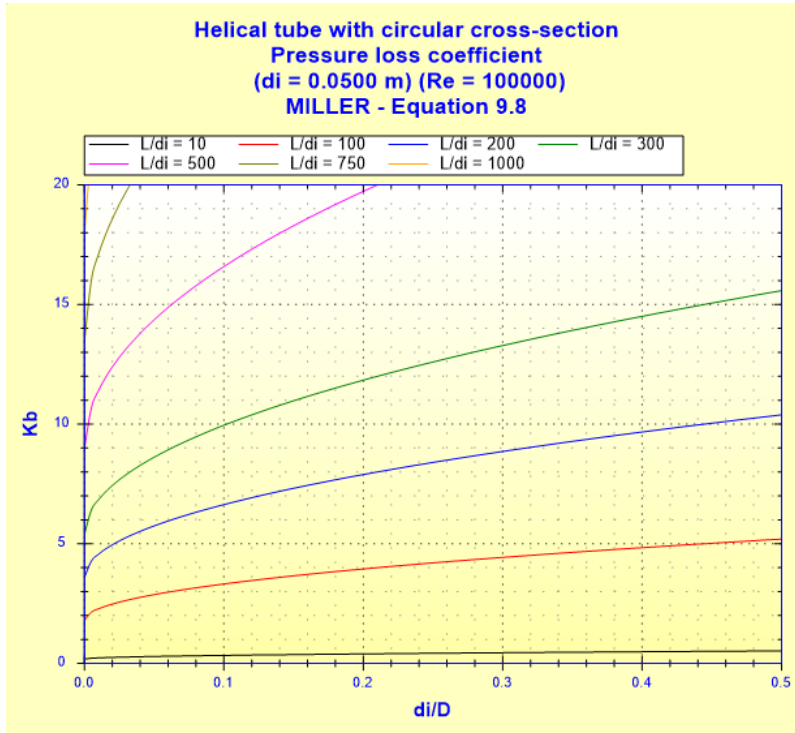
Reynolds number:

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

Local resistance coefficient:

■ $Re_1 \geq 10^4$

$$K_b = \left[0.32 \cdot Re^{-0.25} + 0.048 \cdot \left(\frac{d_i}{D} \right)^{0.5} \right] \cdot \frac{L}{d_i} \quad ([1] \text{ Equation 9.8})$$



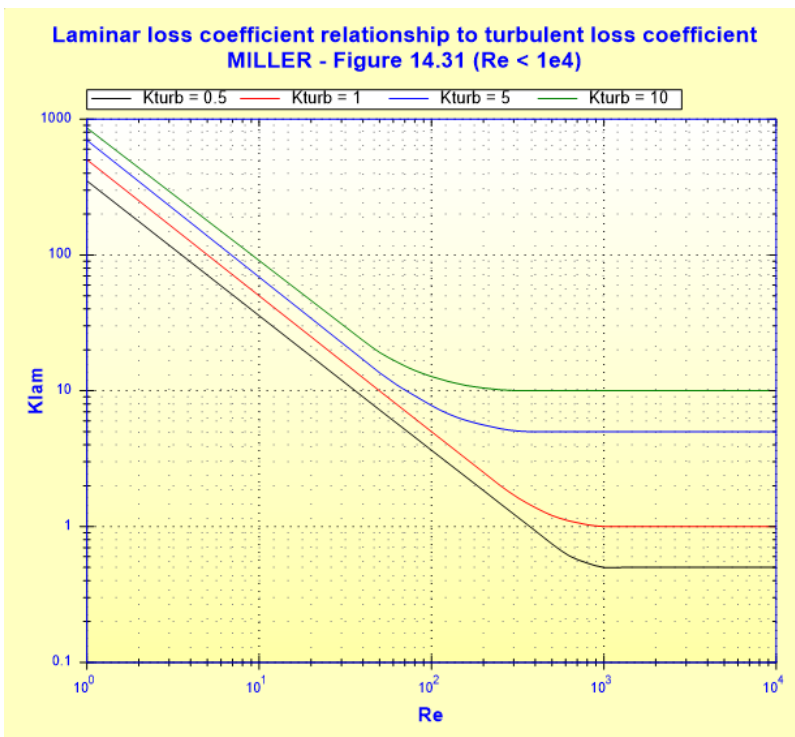
(with $d_i=0.05 \text{ m}$ and $Re=10^5$)

■ $Re_1 < 10^4$

$$K_{lam} = f(K_{turb}, Re_1) \quad ([1] \text{ figure 14.31})$$

where:

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



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

- turbulent flow (Re ≥ 10⁴):

$$K = K_b$$

- laminar flow (Re < 10⁴):

$$K = K_{lam}$$

Total pressure loss (Pa):

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

Total head loss of fluid (m):

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

Hydraulic power loss (W):

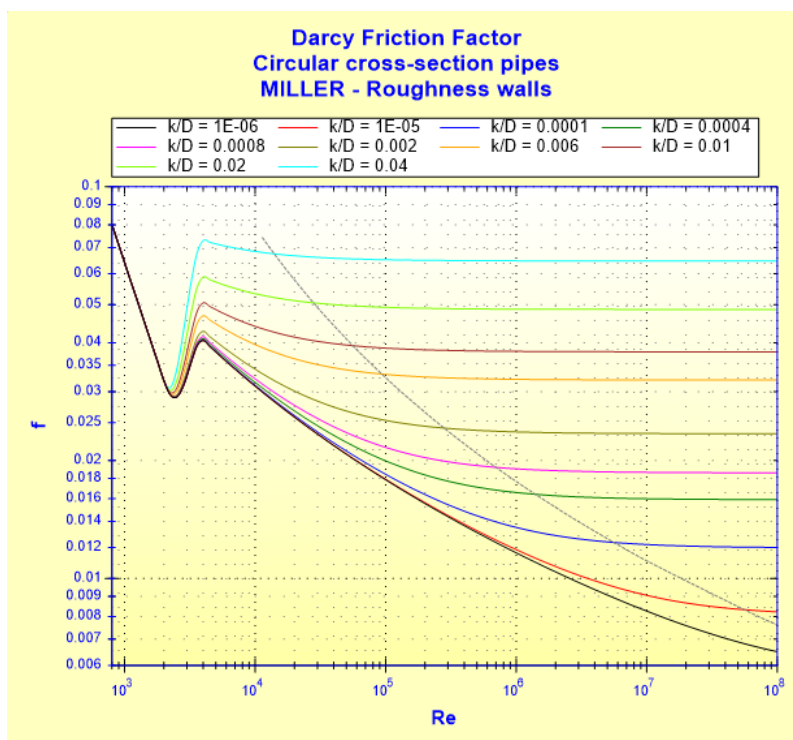
$$Wh = \Delta P \cdot Q$$

Darcy friction factor:

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

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)

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:

HydrauCalc 2021a - [Helical tube with circular cross-section - MILLER (2nd Ed.)]

File Edit Preferences Calculation method Database Tools Help

Fluid characteristics

Fluid : Water @ 1 atm [HC]
Ref.: IAPWS IF97

Temperature : T 20 °C
Pressure : P 1.013 bar

Density : ρ 998.2061 kg/m^3
Dynamic Viscosity : μ 0.00100159 N.s/m^2
Kinematic Viscosity : ν 1.00340E-06 m^2/s

Density Dyn. Visc. Kin. Visc.

Density (kg/m^3) vs Temperature ($^\circ\text{C}$) graph showing a decreasing trend from approximately 998 kg/m^3 at 20 $^\circ\text{C}$ to 950 kg/m^3 at 100 $^\circ\text{C}$.

Geometrical characteristics

U 1.132 m/s (Turbulent)
m 4.9910 kg/s
Q 0.005 m^3/s

Pressure loss
 ΔP 0.09889251 bar
 ΔH 1.0102 m of fluid

Number of turns N 10
Pitch p 0.1 m
Radius r 0.6 m
Diameter d 0.075 m

Complementary results

Designation	Symbol	Value	Unit
Hydraulic diameter	D	0.075	m
Passage cross-section area	A	0.004417865	m^2
Relative radius of curvature	r/d	8	
Developed straight length from the axis	L	37.71238	m
Internal helical tube volume	V	0.1666082	m^3
Mass of fluid in the helical tube	M	166.3093	kg
Ratio 'di/D'	d_i/D	0.0625	kg
Ratio 'L/di'	L/d_i	502.8317	kg
Reynolds number	Re	84595.27	
<input checked="" type="checkbox"/> Resistance coefficient (Equation 9.8)	K_b	15.46885	
Pressure loss coefficient (based on the mean helical tube vel...)	K	15.46885	
Hydraulic power loss	Wh	49.44625	W
<input checked="" type="checkbox"/> Darcy Friction Factor	f	0.01850376	
Straight length of equivalent pressure loss	Leq	62.69882	m

References:

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