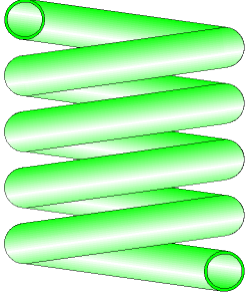




Helical Tube (Coil) Circular Cross-Section (Pipe Flow - Guide)



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):

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

Mean velocity (m/s):

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

Length measured along the axis (m):

$$L = N \cdot \sqrt{(2 \cdot \pi \cdot r)^2 + p^2}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho_m$$

Fluid volume (m³):

$$\text{Vol} = A \cdot L$$

Fluid mass (kg):

$$\text{Mas} = \text{Vol} \cdot \rho_m$$

Reynolds number:

$$N_{Re} = \frac{V \cdot d}{\nu}$$

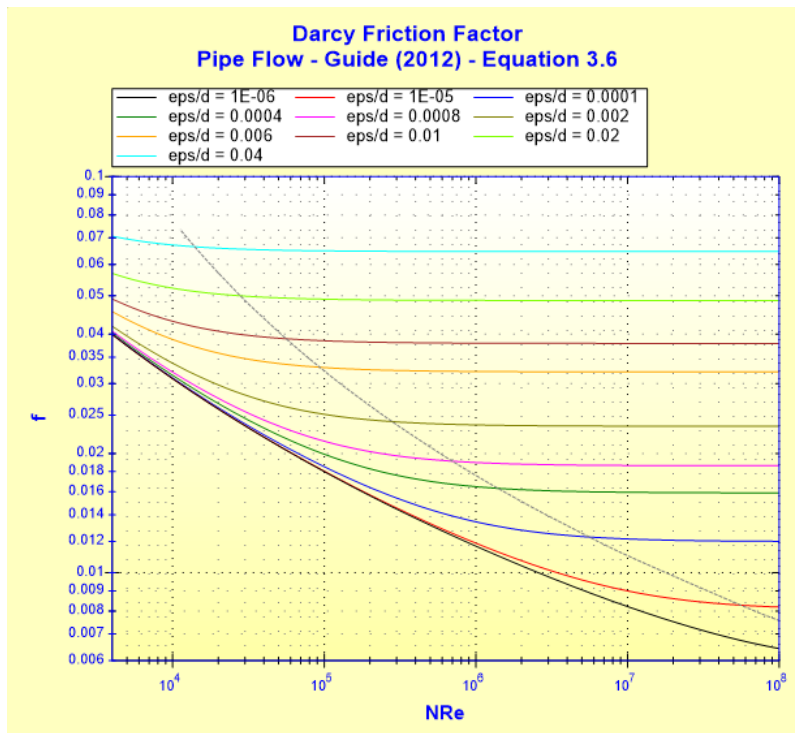
Relative roughness:

$$R_r = \frac{\varepsilon}{d}$$

Darcy friction factor:

$$f = \frac{1}{\left[2 \cdot \log \left(\frac{\varepsilon}{3.7 \cdot d} + \frac{2.51}{N_{Re} \cdot \sqrt{f}} \right) \right]^2}$$

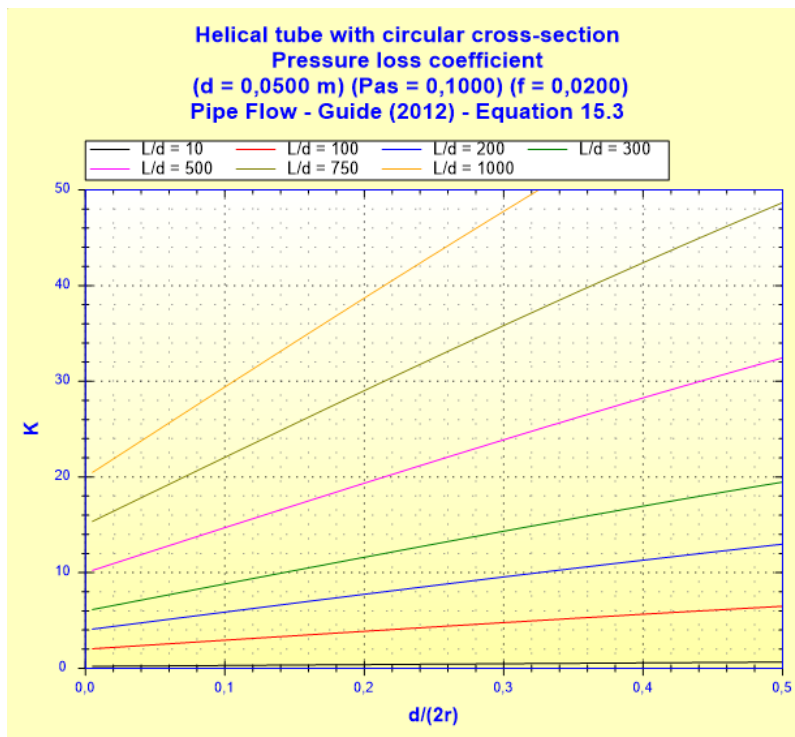
Colebrook-White equation ([1] equation 3.6)



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

$$K = N \cdot \left[f \cdot \frac{\sqrt{(2 \cdot \pi \cdot r)^2 + p^2}}{d} + 0.2 + 4.8 \cdot f \right]$$

([1] equation 15.3)



(with d=0.05 m, Pas=0.1 m and

f=0.02)

Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho_m \cdot V^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{V^2}{2 \cdot g}$$

Hydraulic power loss (W):

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

Straight length of equivalent pressure loss (m):

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

Symbols, Definitions, SI Units:

d	Internal diameter of the helical tube (m)
A	Cross-section area (m ²)
Q	Volume flow rate (m ³ /s)
V	Mean velocity (m/s)
N	Number of turns constituting the helical tube ()
p	Pitch of the helical tube (m)
r	Radius of curvature (m)
L	Length measured along the axis (m)
G	Mass flow rate (kg/s)
Vol	Fluid volume (m ³)

Mas	Fluid mass (kg)
N _{Re}	Reynolds number ()
R _r	Relative roughness ()
ε	Absolute roughness of walls (m)
f	Darcy friction factor
K	Total pressure loss coefficient (based on mean velocity in helical tube) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
L _{eq}	Straight length of equivalent pressure loss (m)
ρ _m	Fluid density (kg/m ³)
ν	Fluid kinematic viscosity (m ² /s)
g	Gravitational acceleration (m/s ²)

Validity range:

- turbulent flow regime (N_{Re} ≥ 10⁴)
- stabilized flow upstream of the helical tube

Example of application:

The screenshot shows the HydraulCalc 2021a software interface. The main window is titled "HydrauCalc 2021a - [Helical tube with circular cross-section - Pipe Flow - Guide (2012)]". The interface is divided into several sections:

- Fluid characteristics:**
 - Fluid: Water @ 1 atm [HC]
 - Ref.: IAPWS IF97
 - Temperature: T = 20 °C
 - Pressure: P = 1.013 bar
 - Density: ρ = 998.2061 kg/m³
 - Dynamic Viscosity: μ = 0.00100159 N.s/m²
 - Kinematic Viscosity: ν = 1.00340E-06 m²/s
 - Graph: Density (kg/m³) vs Temperature (°C) showing a decreasing trend from 1000 at 10°C to approximately 950 at 100°C.
- Geometrical characteristics:**
 - Velocity: V = 1.132 m/s (Turbulent)
 - Mass flow rate: G = 4.9910 kg/s
 - Volume flow rate: Q = 0.005 m³/s
 - Pressure loss: ΔP = 0.08062534 bar
 - Head loss: ΔH = 0.8236 m of fluid
 - Diagram: A 3D model of a helical tube with the following parameters:
 - Radius: r = 0.6 m
 - Number of turns: N = 10
 - Pitch: p = 0.1 m
 - Relative roughness: ε/d = 1.0E-05
 - Tube diameter: d = 0.075 m
- Complementary results:**

Designation	Symbol	Value	Unit
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	Vol	0.1666082	m ³
Mass of fluid in the helical tube	Mas	166.3093	kg
Relative roughness	ε/d	0.0001333333	
Ratio 'd/(2r)'	d/(2r)	0.0625	kg
Ratio 'L/d'	L/d	502.8317	kg
Reynolds number	NRe	84595.27	
Relative roughness	Rr	0.0001333333	
Darcy Friction Factor (Equation 3.6)	f	0.01926448	
Coefficient of local resistance (Equation 15.3)	K	12.61149	
Pressure loss coefficient (based on the mean helical tube vel...)	K	12.61149	
Hydraulic power loss	Wh	40.31267	W
Straight length of equivalent pressure loss	Leq	49.09873	m

References:

[1] Pipe Flow: A Practical and Comprehensive Guide. Donald C. Rennels and Hobart M. Hudson. (2012)

HydrauCalc
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