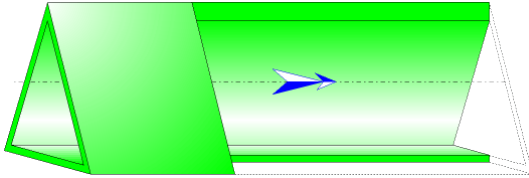




Straight Pipe Triangular Cross-Section and Smooth Walls (IDELCHIK)



Model description:

This model of component calculates the major head loss (pressure drop) of a horizontal straight pipe of triangular and constant cross-section.

In addition, the flow is assumed fully developed and stabilized.

The head loss is due to the friction of the fluid on the inner walls of the piping and is calculated with the Darcy formula. The inner wall of the piping is supposed to completely smooth (without roughness).

Darcy friction factor is determined:

- for laminar flow regime by the law of Hagen-Poiseuille,
- for turbulent flow regime by the explicit Filonenko and Althsul equation,
- for critical flow regime by interpolation between friction factors of laminar and turbulent flow.

Model formulation:

Half top angle (°):

$$\beta = \tan^{-1}\left(\frac{a_0}{2 \cdot h}\right)$$

Hydraulic diameter (m):

$$D_h = \frac{2 \cdot h}{1 + \sqrt{\frac{1}{\tan^2(\beta)} + 1}}$$

Cross-section area (m²):

$$F_0 = \frac{a_0}{2} \cdot h$$

Mean velocity (m/s):

$$w_0 = \frac{Q}{F_0}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Fluid volume in the pipe (m³):

$$V = F_0 \cdot l$$

Fluid mass in the pipe (kg):

$$M = V \cdot \rho$$

Reynolds number:

$$Re = \frac{w_0 \cdot D_h}{\nu}$$

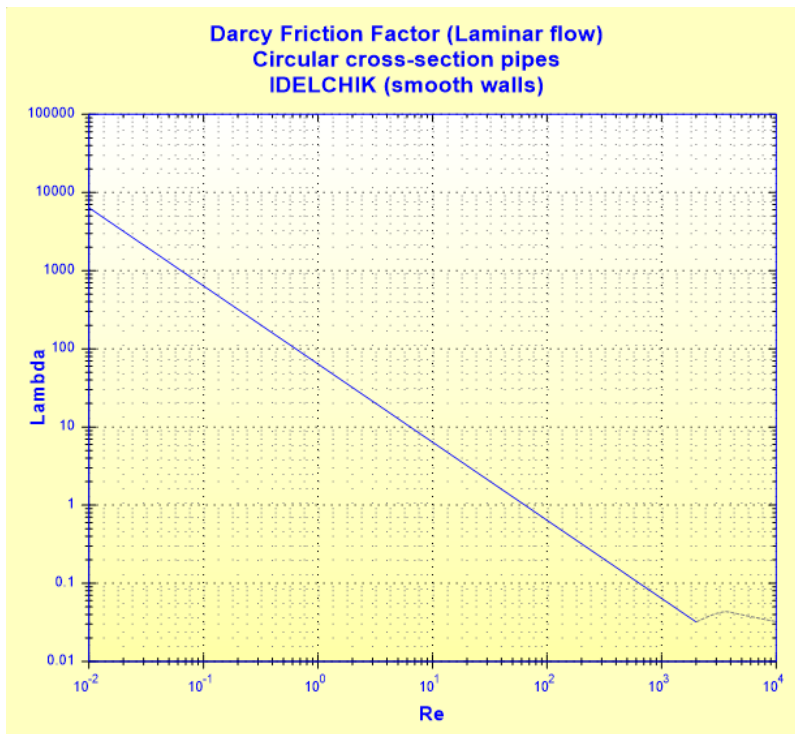
Darcy friction factor for circular cross-section:

- laminar flow regime ($Re \leq 2000$):

Hagen-Poiseuille law

$$\lambda_{circ} = \frac{64}{Re}$$

([1] diagram 2.1)

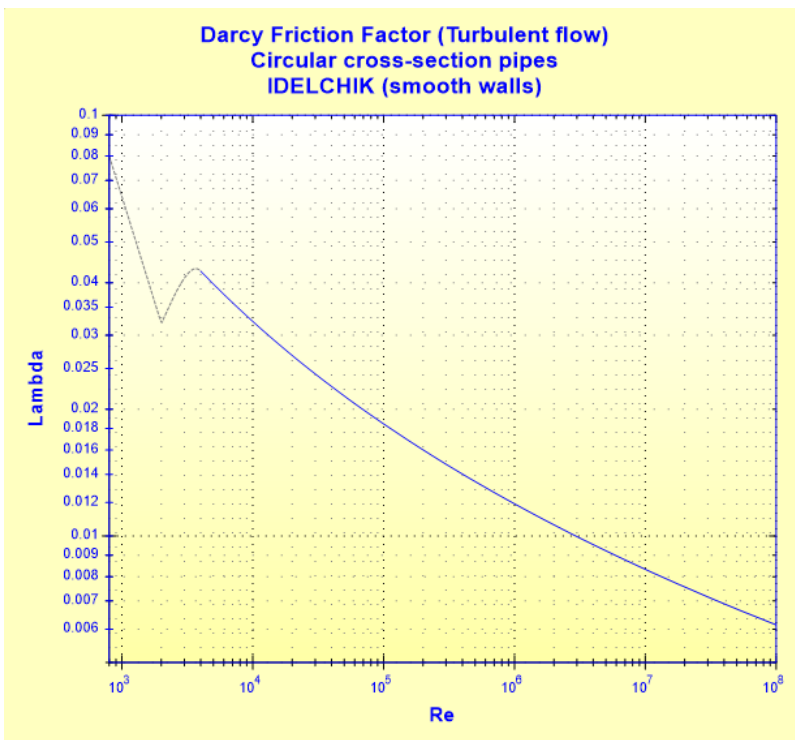


- turbulent flow regime ($Re \geq 4000$):

Filonenko and Althsul Equation

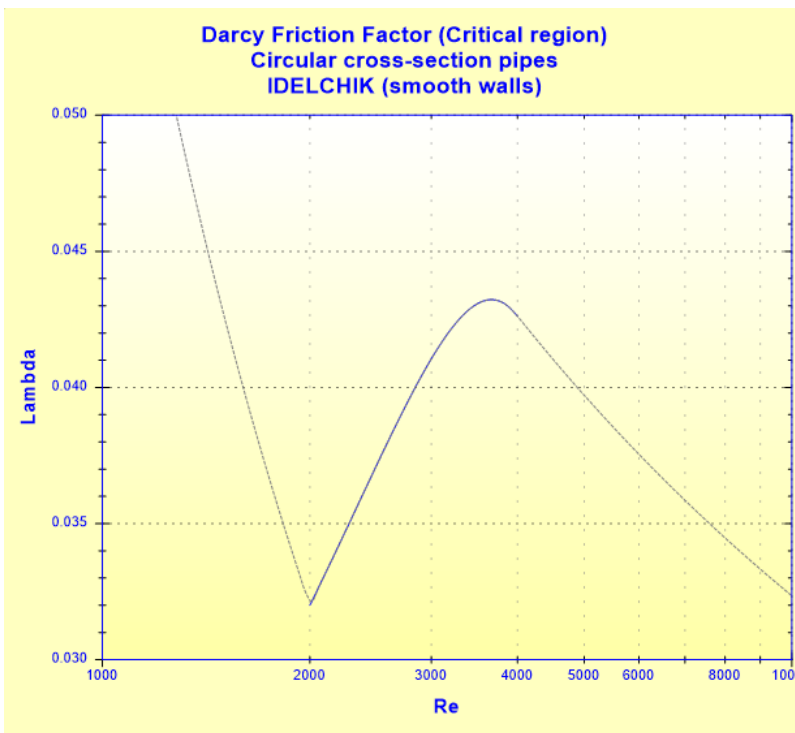
$$\lambda_{circ} = \frac{1}{[1.8 \cdot \log(Re) - 1.64]^2}$$

([1] diagramme 2.1)

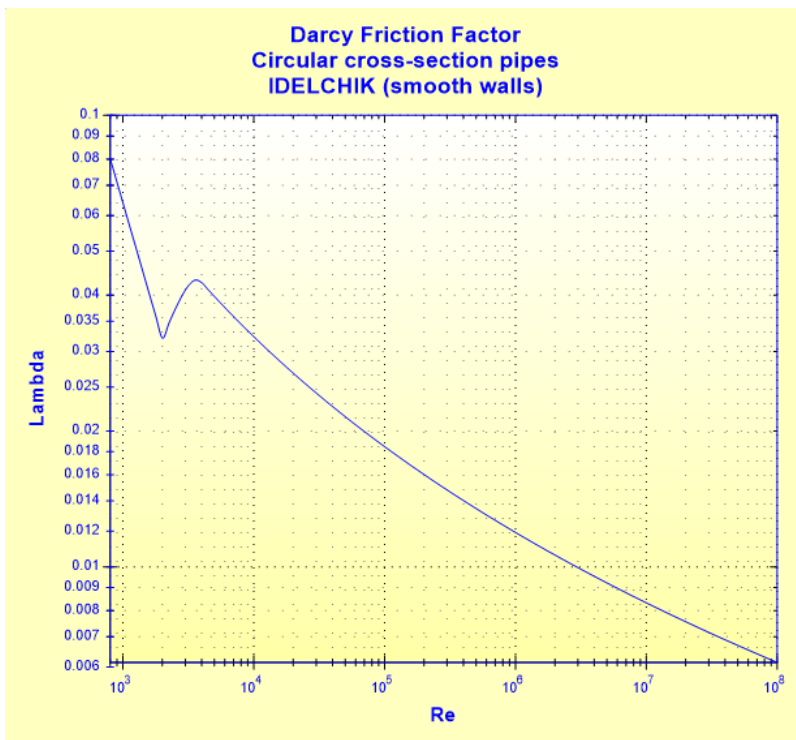


- critical flow regime ($2000 < Re < 4000$):
interpolation between laminar and turbulent flows

$$\lambda_{circ} = f(Re) \quad ([1] \text{ diagram 2.1})$$



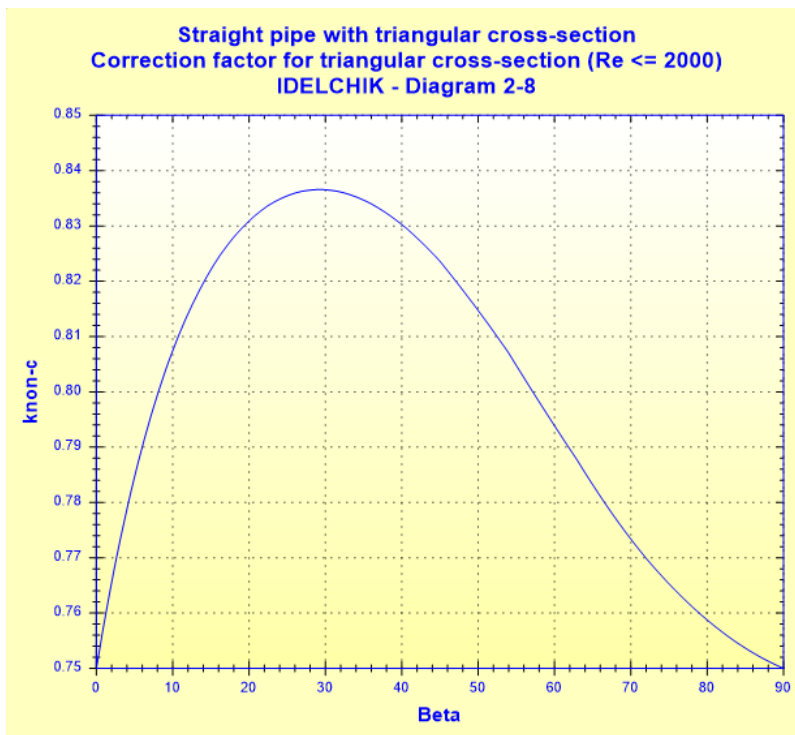
- all flow regimes:



Correction for Darcy friction factor for triangular cross-section:

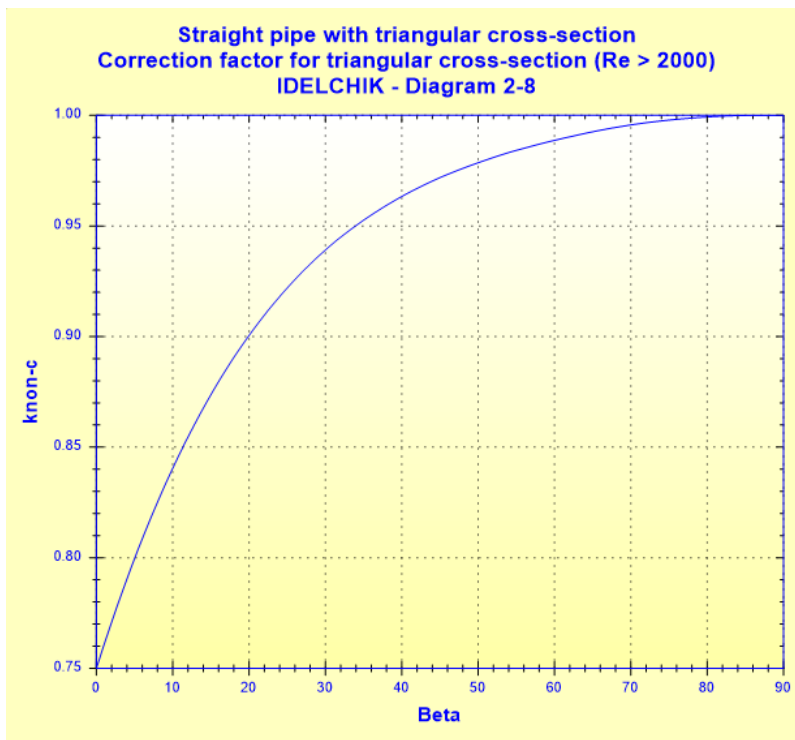
- laminar flow ($Re \leq 2000$):

$$k_{non-c} = f(\beta) \quad ([1] \text{ diagram 2.8})$$



- turbulent flow ($Re > 2000$):

$$k_{non-c} = f(\beta) \quad ([1] \text{ diagram 2.8})$$



Darcy friction factor for triangular cross-section:

$$\lambda_{tria} = \lambda_{circ} \cdot k_{non-c} \quad ([1] \text{ diagram 2.8})$$

Pressure loss coefficient (based on the mean pipe velocity):

$$\zeta = \lambda_{tria} \cdot \frac{l}{D_h} \quad ([1] \text{ diagram 2.8})$$

Total pressure loss (Pa):

$$\Delta P = \zeta \cdot \frac{\rho \cdot w_0^2}{2} \quad ([1] \text{ diagram 2.8})$$

Total head loss of fluid (m):

$$\Delta H = \zeta \cdot \frac{w_0^2}{2 \cdot g}$$

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

a_0	Cross-section base (m)
h	Cross-section height(m)
β	Half top angle (°)
D_h	Hydraulic diameter (m)
F_0	Cross-sectional area (m ²)
Q	Volume flow rate (m ³ /s)
w_0	Mean velocity (m/s)

G	Mass flow rate (kg/s)
l	Pipe length (m)
V	Fluid volume in the pipe (m^3)
M	Fluid mass in the pipe (kg)
Re	Reynolds number ()
λ_{circ}	Darcy friction factor for circular cross-section ()
k_{non-c}	Correction for Darcy friction factor for noncircular cross-section ()
λ_{tria}	Darcy friction factor for triangular cross-section ()
ζ	Pressure loss coefficient (based on the mean pipe velocity) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
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, critical and turbulent ($Re \leq 10^8$)
- stabilized flow

Example of input data and results:

The screenshot shows the HydraulCalc 2019b software interface. The main window is titled "HydrauCalc 2019b - [Straight pipe triangular cross-section and smooth walls - IDELCHIK (3rd Ed.)]". 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: $\rho = 998.2061$ kg/m³
 - Dynamic Viscosity: $\mu = 0.00100159$ N.s/m²
 - Kinematic Viscosity: $\nu = 1.00340E-06$ m²/s
- Geometrical characteristics:**
 - Top angle: $\beta = 45.0$ °
 - Side length: $a_0 = 0.1$ m
 - Length: $l = 1$ m
 - Height: $h = 0.05$ m
 - Mass flow rate: $G = 4.9910$ kg/s
 - Volume flow rate: $Q = 0.005$ m³/s
 - Mean velocity: $w_0 = 2.0$ m/s (Turbulent)
 - Pressure loss: $\Delta P = 0.009010563$ bar
 - Head loss: $\Delta H = 0.0920$ m of fluid
- Complementary results:**

Designation	Symbol	Value	Unit
Hydraulic diameter	D_h	0.04142136	m
Top angle	2β	90	°
Pipe cross-section area	F_0	0.0025	m ²
Internal pipe volume	V	0.0025	m ³
Mass of fluid in the pipe	M	2.495515	kg
Reynolds number	Re	82562.24	
Friction factor for circular cross-section	λ_{circ}	0.01923555	
Correction factor for triangular cross-section	k_{non-c}	0.9719	
Friction factor for triangular cross-section	λ_{tria}	0.01869503	
Pressure loss per length unit		0.009010563	bar/m
Pressure loss coefficient (based on the mean pipe velocity)	ζ	0.4513379	
Hydraulic power loss	Wh	4.505281	W

References:

