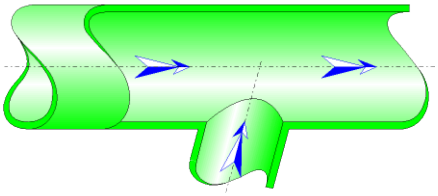
Combining sharp-edged junction
Circular Cross-Section
(IDELCHIK)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a combining sharp-edged junction.

The head loss by friction in the inlet and outlet piping is not taken into account in this component.

Model formulation:

Cross-sectional area of the lateral branch (m²):

$$F_s = \pi \cdot \frac{D_s^2}{4}$$

Cross-sectional area of the common branch and the straight branch (m²):

$$F_c = \pi \cdot \frac{D_c^2}{4}$$

Volume flow rate in the common branch (m³/s):

$$Q_c = Q_s + Q_{st}$$

Mean velocity in the lateral branch (m/s):

$$w_s = \frac{Q_s}{F_s}$$

Mean velocity in the straight branch (m/s):

$$w_{st} = \frac{Q_{st}}{F_c}$$

Mean velocity in the common branch (m/s):

$$w_c = \frac{Q_c}{F_c}$$

Mass flow rate in the lateral branch (kg/s):

$$G_s = Q_s \cdot \rho$$

Mass flow rate in the straight branch (kg/s):

$$G_{st} = Q_{st} \cdot \rho$$

Mass flow rate in the common branch (kg/s):

$$G_c = Q_c \cdot \rho$$

Reynolds number in the lateral branch:

$$\mathrm{Re}_s = \frac{w_s \cdot D_s}{\nu}$$

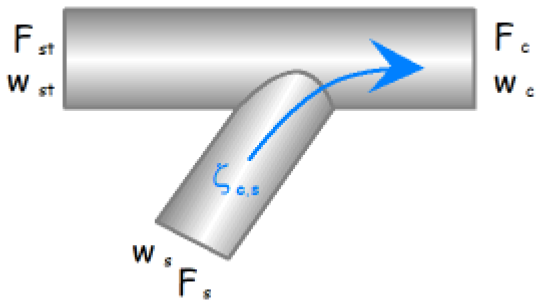
Reynolds number in the straight branch:

$$\mathrm{Re}_{st} = \frac{w_{st} \cdot D_c}{\nu}$$

Reynolds number in the common branch:

$$\mathrm{Re}_c = \frac{w_c \cdot D_c}{\nu}$$

Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch):



■ $\mathrm{Re}_c \geq 4000$

$$\zeta_{c.s} = A \cdot \zeta'_{c.s}$$ ([1] diagram 7.1 7.2 7.3 7.4)

with:

Values of A

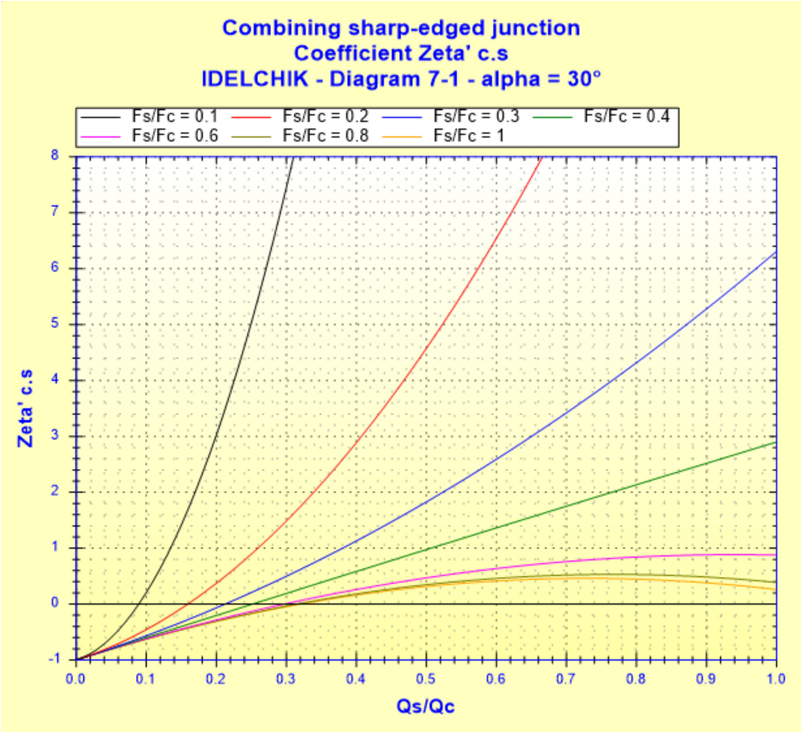
F_s / F_c	≤ 0.35	> 0.35	
Q_s / Q_c	≤ 1	≤ 0.4	> 0.4
A	1	$0.9 \cdot \left(1 - \frac{Q_s}{Q_c}\right)$	0.55

([1] table 7-1)

- Angle $\alpha = 30°$

$$\zeta'_{c.s} = 1 + \left(\frac{Q_s}{Q_c} \cdot \frac{F_c}{F_s} \right)^2 - 2 \cdot \left(1 - \frac{Q_s}{Q_c} \right)^2 - 1.74 \cdot \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c} \right)^2$$

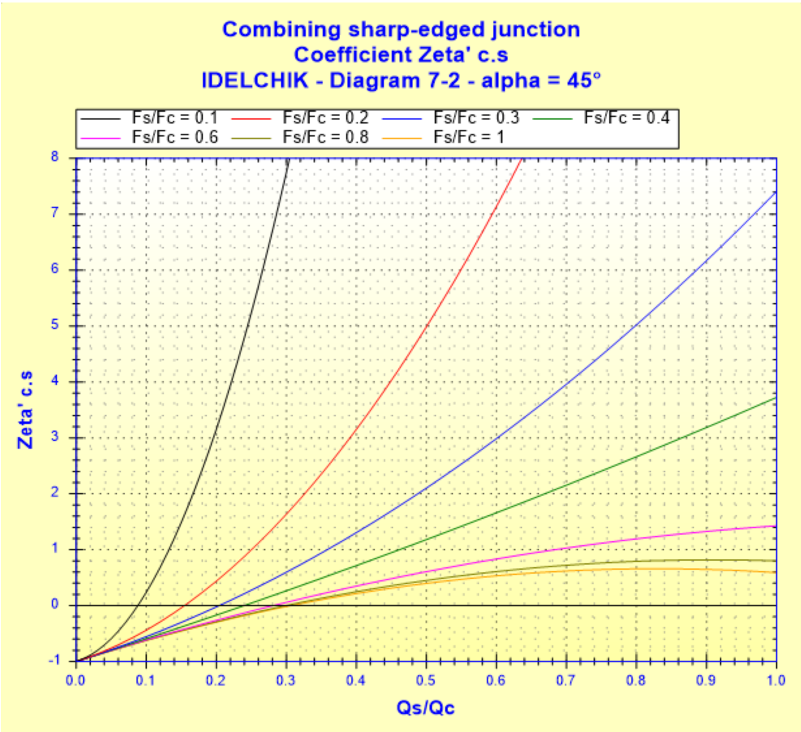
([1] diagram 7.1)



- Angle $\alpha = 45°$

$$\zeta'_{c.s} = 1 + \left(\frac{Q_s}{Q_c} \cdot \frac{F_c}{F_s} \right)^2 - 2 \cdot \left(1 - \frac{Q_s}{Q_c} \right)^2 - 1.41 \cdot \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c} \right)^2$$

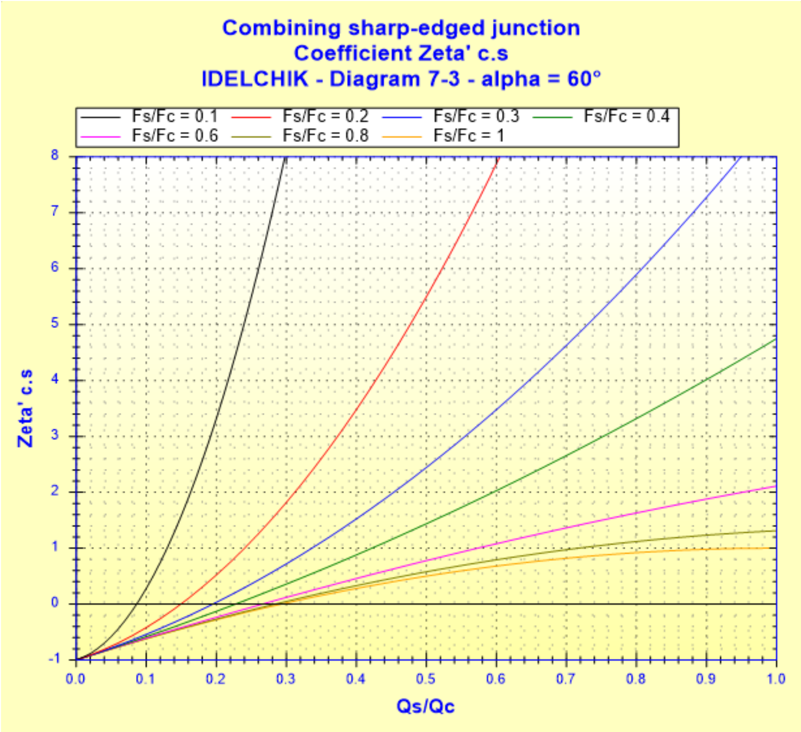
([1] diagram 7.2)



- Angle $\alpha = 60°$

$$\zeta'_{c.s} = 1 + \left(\frac{Q_s}{Q_c} \cdot \frac{F_c}{F_s}\right)^2 - 2 \cdot \left(1 - \frac{Q_s}{Q_c}\right)^2 - \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c}\right)^2$$

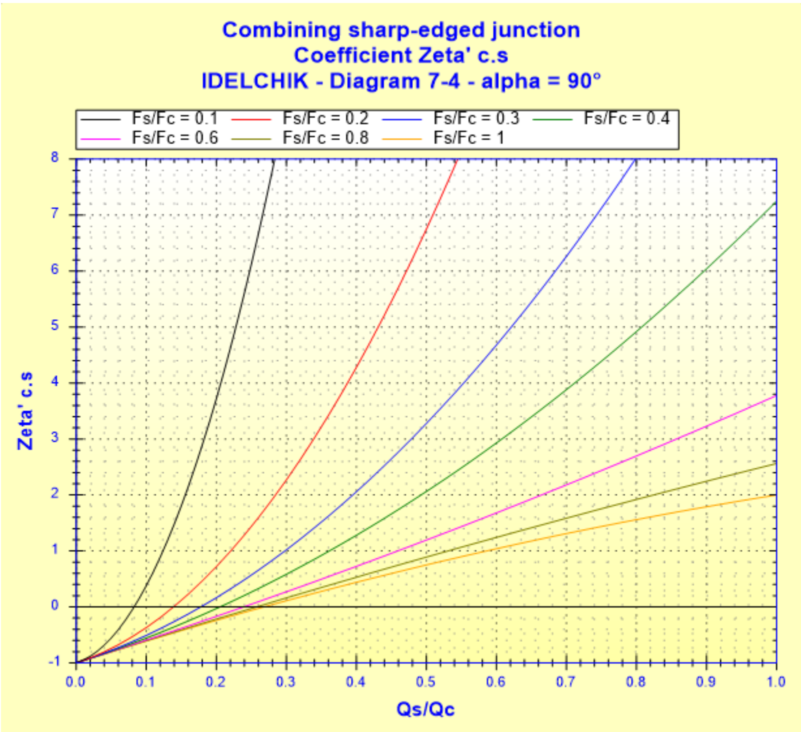
([1] diagram 7.3)



- Angle $\alpha = 90°$

$$\zeta'_{c.s} = 1 + \left(\frac{Q_s}{Q_c} \cdot \frac{F_c}{F_s}\right)^2 - 2 \cdot \left(1 - \frac{Q_s}{Q_c}\right)^2$$

([1] diagram 7.4)



For any angles α between 30 ° and 90 °, the coefficient $\zeta'_{c.s}$ is obtained by linear interpolation between the values of $\zeta'_{c.s}$ calculated at 30 °, 45 °, 60 ° and 90 °.

■ $Re_c \leq 2000$

$$\zeta_{c.s} = 2 \cdot \zeta^t{}_{c.s} + \frac{150}{Re_c}$$

([1] equation §30)

with

$$\zeta^t{}_{c.s} = A \cdot \left[1 + \left(\frac{Q_s}{Q_c} \cdot \frac{F_c}{F_s} \right)^2 - 2 \cdot \frac{F_c}{F_{st}} \cdot \left(1 - \frac{Q_s}{Q_c} \right)^2 - 2 \cdot \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c} \right)^2 \cdot \cos(\alpha) \right] + K_s$$

([1] equation 7.1)

with :

Values of A

F_s / F_c	≤ 0.35	> 0.35	
Q_s / Q_c	≤ 1	≤ 0.4	> 0.4
A	1	$0.9 \cdot \left(1 - \frac{Q_s}{Q_c}\right)$	0.55

([1] table 7-1)

$$K_s = 0$$

■ $2000 < Re_c < 4000$

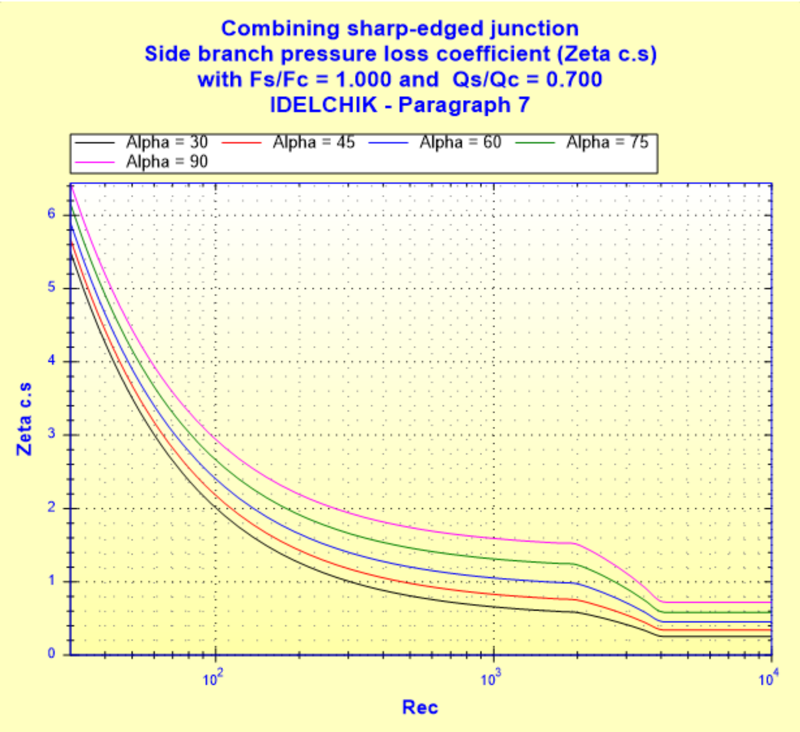
linear interpolation

$$\zeta_{c.s} = \zeta^l{}_{c.s} \cdot \left(1 - \frac{Re_c - 2000}{2000} \right) + \zeta^t{}_{c.s} \cdot \left(\frac{Re_c - 2000}{2000} \right)$$

with:

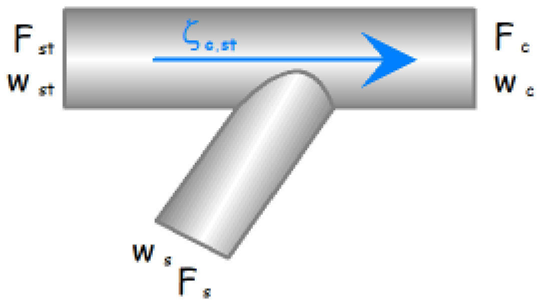
$\zeta^l{}_{c.s}$ = laminar coefficient obtained with Re_c = 2000

$\zeta^t{}_{c.s}$ = turbulent coefficient obtained with Re_c = 4000



$\zeta_{c.s}$ for Re_c < 4000 and with F_s/F_c = 1 and Q_s/Q_c = 0.7

Pressure loss coefficient of the straight branch (based on mean velocity in the common branch):

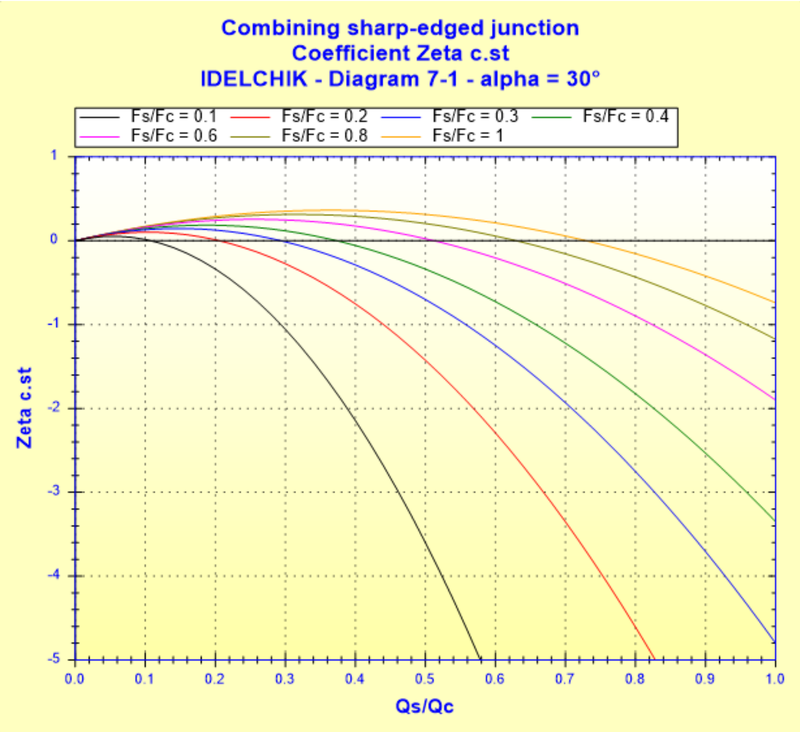


■ $Re_c \geq 4000$

- Angle $\alpha = 30°$

$$\zeta_{c.st} = 1 - \left(1 - \frac{Q_s}{Q_c}\right)^2 - 1.74 \cdot \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c}\right)^2$$

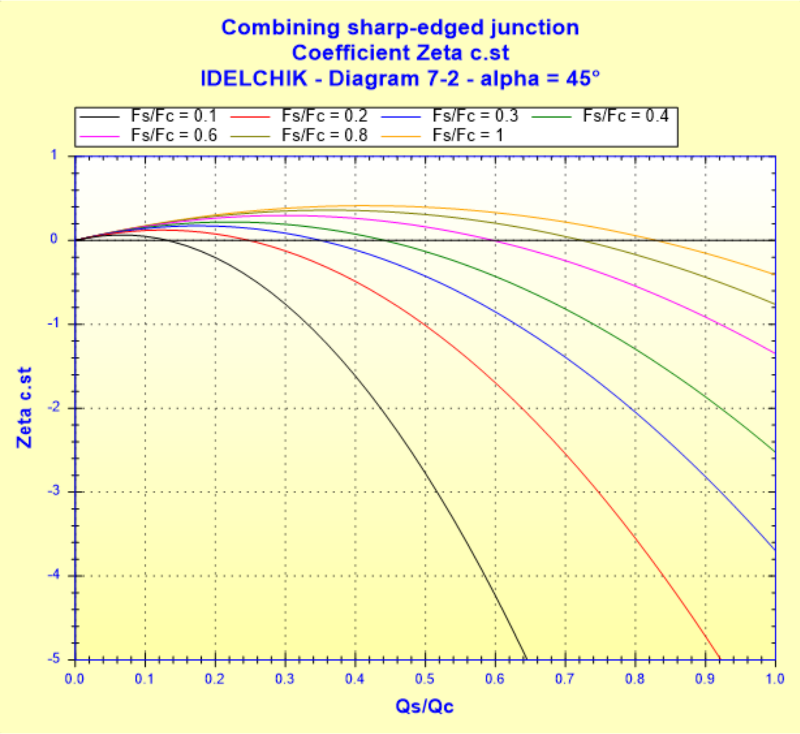
([1] diagram 7.1)



- Angle $\alpha = 45°$

$$\zeta_{c.st} = 1 - \left(1 - \frac{Q_s}{Q_c}\right)^2 - 1.41 \cdot \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c}\right)^2$$

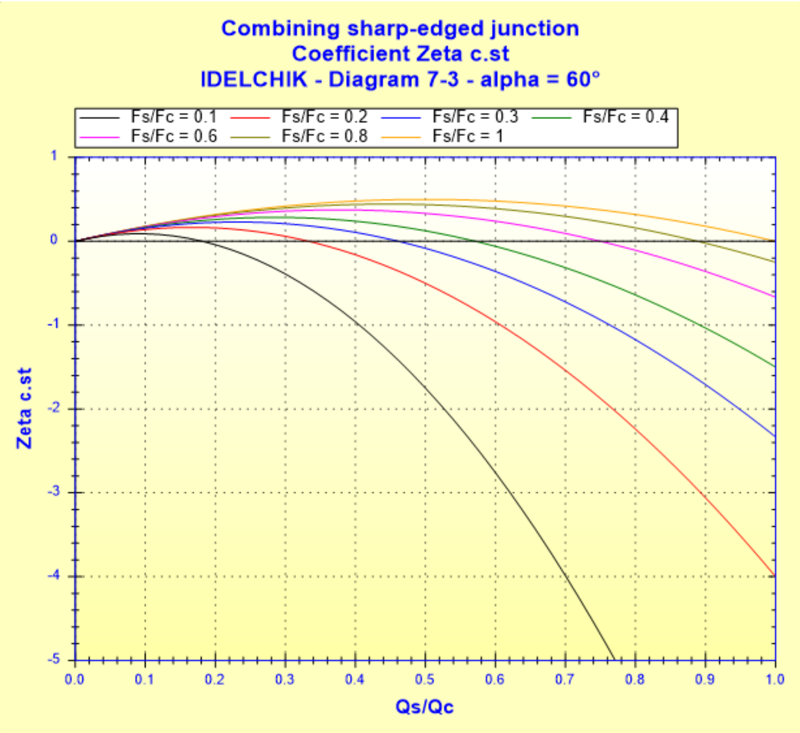
([1] diagram 7.2)



● Angle $\alpha = 60°$

$$\zeta_{c.st} = 1 - \left(1 - \frac{Q_s}{Q_c}\right)^2 - \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c}\right)^2$$

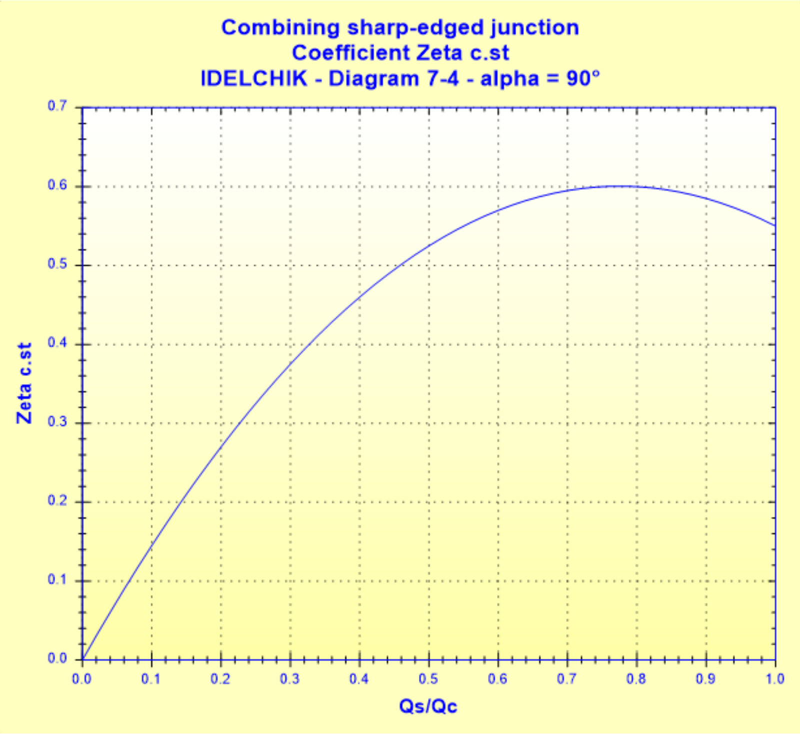
([1] diagram 7.3)



● Angle $\alpha = 90°$

$$\zeta_{c.st} = 1.55 \cdot \frac{Q_s}{Q_c} - \left(\frac{Q_s}{Q_c}\right)^2$$

([1] diagram 7.4)



For any angles α between 30 ° and 90 °, the coefficient $\zeta_{c.st}$ is obtained by linear interpolation between the values of $\zeta_{c.st}$ calculated at 30 °, 45 °, 60 ° and 90 °.

■ $Re_c \leq 2000$

$$\zeta_{c.st} = 2 \cdot \zeta^{l}_{c.s} + a_0 \cdot \left(1 - \frac{Q_s}{Q_c}\right)^2 - \left(1.6 - 0.3 \cdot \frac{F_s}{F_c}\right) \cdot \left(\frac{F_c}{F_s} \cdot \frac{Q_s}{Q_c}\right)^2$$

([1] equation §30)

with:

Values of a_0

F_s / F_c	≤ 0.35	> 0.35	
Q_s / Q_c	≤ 1	≤ 0.2	> 0.2
a_0	$1.8 - \frac{Q_s}{Q_c}$	$1.8 - 4 \cdot \frac{Q_s}{Q_c}$	$1.2 - \frac{Q_s}{Q_c}$

([1] table 7-6)

$$\zeta^{l}_{c.s} = 2 \cdot \zeta^{t}_{c.s} + \frac{150}{Re_c}$$

([1] équation 7.6)

with:

$$\zeta^{t}_{c.s} = A \cdot \left[1 + \left(\frac{Q_s}{Q_c} \cdot \frac{F_c}{F_s}\right)^2 - 2 \cdot \frac{F_c}{F_{st}} \cdot \left(1 - \frac{Q_s}{Q_c}\right)^2 - 2 \cdot \frac{F_c}{F_s} \cdot \left(\frac{Q_s}{Q_c}\right)^2 \cdot \cos(\alpha)\right] + K_s$$

([1] équation 7.1)

with:

Values of A

F_s / F_c	≤ 0.35	> 0.35	
Q_s / Q_c	≤ 1	≤ 0.4	> 0.4
A	1	$0.9 \cdot \left(1 - \frac{Q_s}{Q_c}\right)$	0.55

([1] table 7-1)

$$K_S = 0$$

■ $2000 < Re_c < 4000$

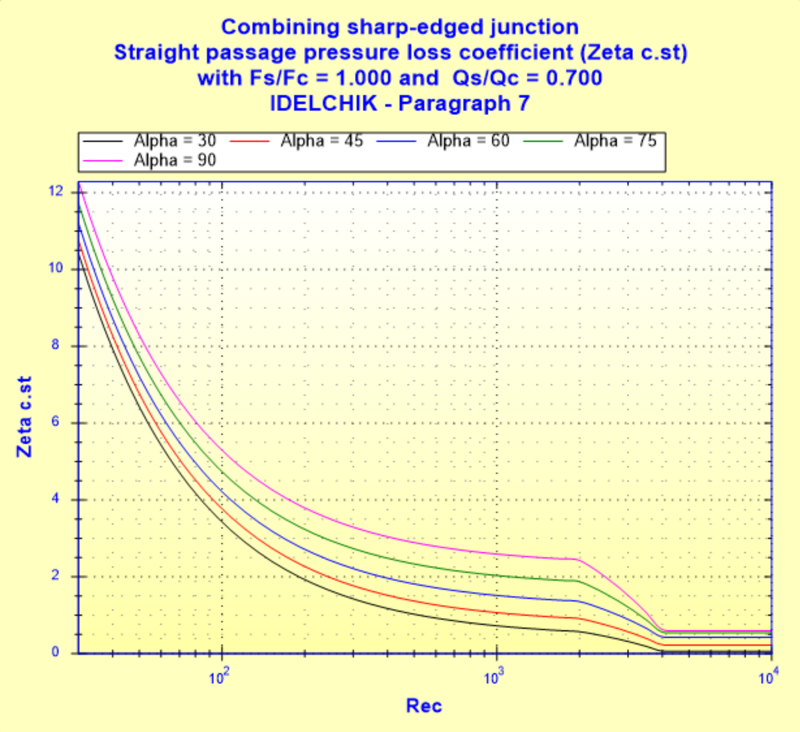
linear interpolation

$$\zeta_{c.s} = \zeta^l{}_{c.s} \cdot \left(1 - \frac{Re_c - 2000}{2000}\right) + \zeta^t{}_{c.s} \cdot \left(\frac{Re_c - 2000}{2000}\right)$$

with:

$\zeta^l{}_{c.s}$ = laminar coefficient obtained with Re_c = 2000

$\zeta^t{}_{c.s}$ = turbulent coefficient obtained with Re_c = 4000



$\zeta_{c.s}$ for Re_c < 4000 and with F_s/F_c = 1 and Q_s/Q_c = 0.7

Pressure loss in the lateral branch (Pa):

$$\Delta P_{c.s} = \zeta_{c.s} \cdot \frac{\rho \cdot w_c{}^2}{2}$$

Pressure loss in the straight branch (Pa):

$$\Delta P_{c.st} = \zeta_{c.st} \cdot \frac{\rho \cdot w_c{}^2}{2}$$

Head loss of fluid in the lateral branch (m):

$$\Delta H_{c.s} = \zeta_{c.s} \cdot \frac{w_c{}^2}{2 \cdot g}$$

Head loss of fluid in the straight branch (m):

$$\Delta H_{c.st} = \zeta_{c.st} \cdot \frac{w_c{}^2}{2 \cdot g}$$

Hydraulic power loss in the lateral branch (W):

$$Wh_s = \Delta P_{c.s} \cdot Q_s$$

Hydraulic power loss in the straight branch (W):

$$Wh_{st} = \Delta P_{c.st} \cdot Q_{st}$$

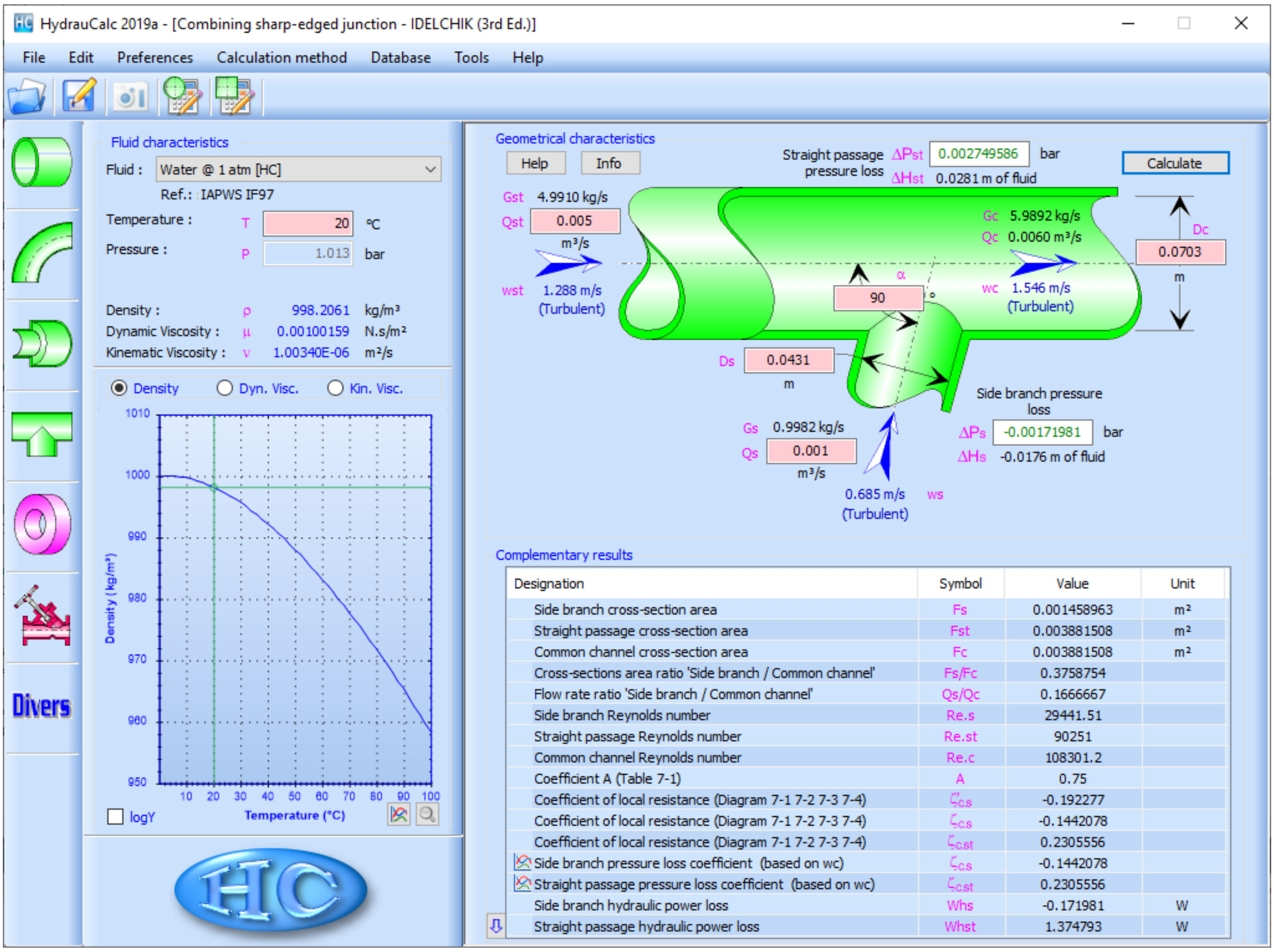
Symbols, Definitions, SI Units:

D_s	Diameter of the lateral branch (m)
D_c	Diameter of the common branch and the straight branch (m)
F_s	Cross-sectional area of the lateral branch (m²)
F_c	Cross-sectional area of the common branch and the straight branch (m²)
Q_s	Volume flow rate in the lateral branch (m³/s)
w_s	Mean velocity in the lateral branch (m/s)
Q_{st}	Volume flow rate in the straight branch (m³/s)
w_{st}	Mean velocity in the straight branch (m/s)
Q_c	Volume flow rate in the common branch (m³/s)
w_c	Mean velocity in the common branch (m/s)
G_s	Mass flow rate in the lateral branch (kg/s)
G_{st}	Mass flow rate in the straight branch (kg/s)
G_c	Mass flow rate in the common branch (kg/s)
Re_s	Reynolds number in the lateral branch ()
Re_{st}	Reynolds number in the straight branch ()
Re_c	Reynolds number in the common branch ()
α	Angle of the lateral branch (m)
$\zeta_{c.s}$	Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch) ()
$\zeta_{c.st}$	Pressure loss coefficient of the straight branch (based on mean velocity in the common branch) ()
ΔP_s	Pressure loss in the lateral branch (Pa)
ΔP_{st}	Pressure loss in the straight branch (Pa)
ΔH_s	Head loss of fluid in the lateral branch (m)
ΔH_{st}	Head loss of fluid in the straight branch (m)
Wh_s	Hydraulic power loss in the lateral branch (W)
Wh_{st}	Hydraulic power loss in the straight branch (W)
ρ	Fluid density (kg/m³)
ν	Fluid kinematic viscosity (m²/s)
g	Gravitational acceleration (m/s²)

Validity range:

- angle of the lateral branch: between 30° and 90°

Example of application:



Designation	Symbol	Value	Unit
Side branch cross-section area	Fs	0.001458963	m²
Straight passage cross-section area	Fst	0.003881508	m²
Common channel cross-section area	Fc	0.003881508	m²
Cross-sections area ratio 'Side branch / Common channel'	Fs/Fc	0.3758754	
Flow rate ratio 'Side branch / Common channel'	Qs/Qc	0.1666667	
Side branch Reynolds number	Re.s	29441.51	
Straight passage Reynolds number	Re.st	90251	
Common channel Reynolds number	Re.c	108301.2	
Coefficient A (Table 7-1)	A	0.75	
Coefficient of local resistance (Diagram 7-1 7-2 7-3 7-4)	ζ'c.s	-0.192277	
Coefficient of local resistance (Diagram 7-1 7-2 7-3 7-4)	ζc.s	-0.1442078	
Coefficient of local resistance (Diagram 7-1 7-2 7-3 7-4)	ζc.st	0.2305556	
Side branch pressure loss coefficient (based on wc)	ζc.s	-0.1442078	
Straight passage pressure loss coefficient (based on wc)	ζc.st	0.2305556	
Side branch hydraulic power loss	Whs	-0.171981	W
Straight passage hydraulic power loss	Whst	1.374793	W

References:

[1] Handbook of Hydraulic Resistance, 3rd Edition, I.E. Idelchik