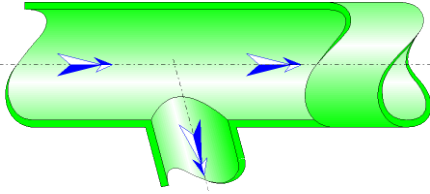




## Dividing sharp-edged junction Circular Cross-Section (IDELCHIK)



### Model description:

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

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

### Model formulation:

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Cross-sectional area of the lateral branch (m<sup>2</sup>):

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

---

Cross-sectional area of the common branch and the straight branch (m<sup>2</sup>):

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

---

Volume flow rate in the common branch (m<sup>3</sup>/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:

$$Re_s = \frac{w_s \cdot D_s}{\nu}$$

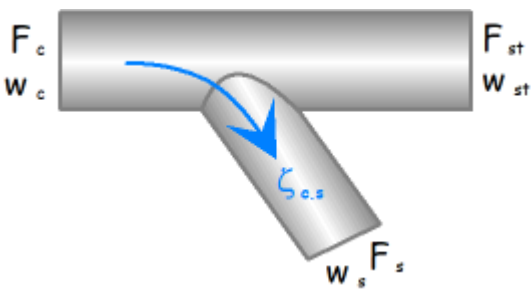
Reynolds number in the straight branch:

$$Re_{st} = \frac{w_{st} \cdot D_c}{\nu}$$

Reynolds number in the common branch:

$$Re_c = \frac{w_c \cdot D_c}{\nu}$$

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



■  $Re_c \geq 4000$

$$\zeta_{c.s} = A' \cdot \zeta'_{c.s} \quad ([1] \text{ diagram 7-18})$$

with:

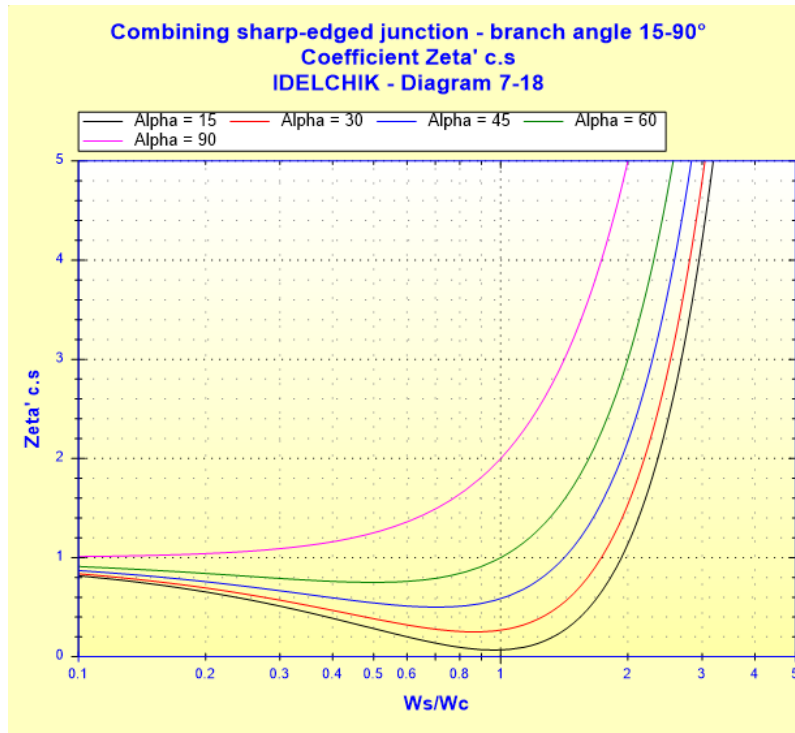
Values of  $A'$

|             |                                   |         |                                   |         |
|-------------|-----------------------------------|---------|-----------------------------------|---------|
| $F_s / F_c$ | $\leq 0.35$                       |         | $> 0.35$                          |         |
| $Q_s / Q_c$ | $\leq 0.4$                        | $> 0.4$ | $\leq 0.6$                        | $> 0.6$ |
| $A'$        | $1.1 - 0.7 \cdot \frac{Q_s}{Q_c}$ | 0.85    | $1.0 - 0.6 \cdot \frac{Q_s}{Q_c}$ | 0.6     |

([1] table 7-4)

$$\zeta'_{c.s} = 1 + \left(\frac{W_s}{W_c}\right)^2 - 2 \cdot \left(\frac{W_s}{W_c}\right) \cdot \cos(\alpha)$$

([1] diagram 7-18)



■  $Re_c \leq 2000$

$$\zeta_{c.s} = (k_1 + 1) \cdot \zeta'_{c.s} + \frac{150}{Re_c}$$

([1] equation S31)

with:

Values of  $k_1$

| $Q_s/Q_c$ | Alpha |     |     |     |
|-----------|-------|-----|-----|-----|
|           | 30°   | 45° | 60° | 90° |
| 0         | 0.9   | 0.9 | 0.9 | 0.9 |
| 0.2       | 1.8   | 1.8 | 1.5 | 1.1 |
| 0.4       | 3.4   | 2.9 | 2.2 | 1.3 |
| 0.6       | 6.1   | 4.3 | 3   | 1.5 |
| 0.8       | 7.2   | 4.3 | 2.7 | 1.4 |
| 1         | 6     | 3.6 | 2.3 | 1.3 |

([1] table 7-7)

$$\zeta^t_{c.s} = A' \cdot \left[ 1 + \left(\frac{W_s}{W_c}\right)^2 - 2 \cdot \frac{W_s}{W_c} \cdot \cos(\alpha) \right] - K'_{st} \cdot \left(\frac{W_s}{W_c}\right)^2$$

([1] equation 7.3)

with:

Values of  $A'$

|             |                                   |         |                                   |         |
|-------------|-----------------------------------|---------|-----------------------------------|---------|
| $F_s / F_c$ | $\leq 0.35$                       |         | $> 0.35$                          |         |
| $Q_s / Q_c$ | $\leq 0.4$                        | $> 0.4$ | $\leq 0.6$                        | $> 0.6$ |
| $A'$        | $1.1 - 0.7 \cdot \frac{Q_s}{Q_c}$ | 0.85    | $1.0 - 0.6 \cdot \frac{Q_s}{Q_c}$ | 0.6     |

([1] table 7-4)

$$K'_{st} = 0$$

■  $2000 < Re_c < 4000$

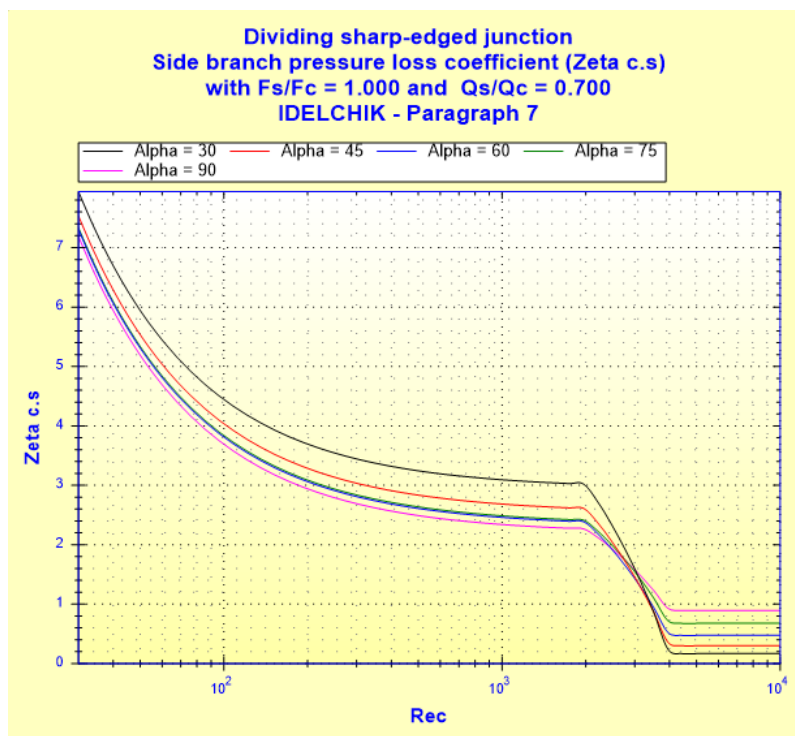
linear interpolation

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

with:

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

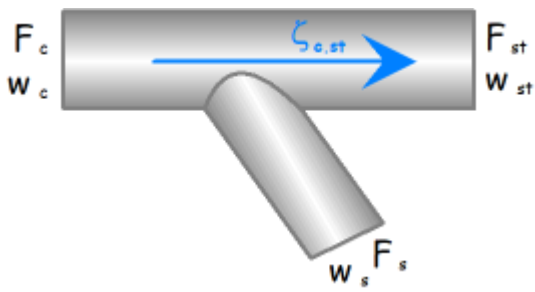
$\zeta^t_{c.s}$  = turbulent coefficient obtained with  $Re_c = 4000$



$\zeta_{c.s}$  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):



■  $Re_c \geq 4000$

$$\zeta_{c.st} = \tau_{st} \cdot \left( \frac{Q_s}{Q_c} \right)^2 \quad ([1] \text{ diagram 7-20})$$

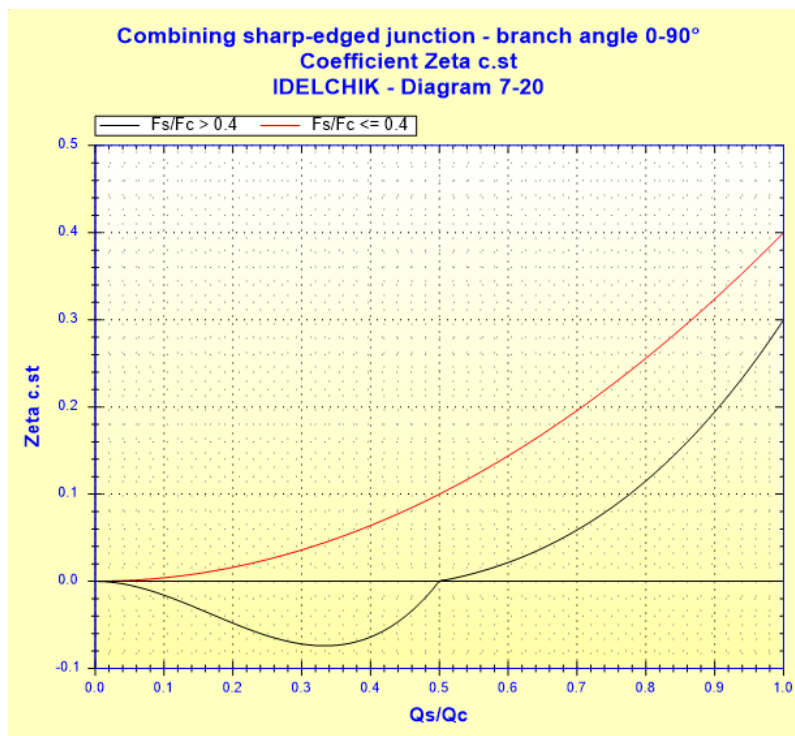
with:

Values of  $\tau_{st}$

| $F_s / F_c$ | $\leq 0.4$ | $> 0.4$                                              |                                                        |
|-------------|------------|------------------------------------------------------|--------------------------------------------------------|
| $Q_s / Q_c$ | 0 - 1.0    | $\leq 0.5$                                           | $> 0.5$                                                |
| $\tau_{st}$ | 0.4        | $2 \cdot \left( 2 \cdot \frac{Q_s}{Q_c} - 1 \right)$ | $0.3 \cdot \left( 2 \cdot \frac{Q_s}{Q_c} - 1 \right)$ |

([1])

diagram 7-20)



■  $Re_c \leq 2000$

$$\zeta_{c.st} = 3 \cdot \zeta_{c.st}^t + \frac{33}{Re_c} \quad ([1] \text{ equation S31})$$

with:

$$\zeta_{c.st}^t = \tau_{st} \cdot \left( \frac{Q_s}{Q_c} \right)^2 \quad ([1] \text{ equation 7-4})$$

with:

Values of  $\tau_{st}$

|             |            |                                                      |                                                        |
|-------------|------------|------------------------------------------------------|--------------------------------------------------------|
| $F_s / F_c$ | $\leq 0.4$ | $> 0.4$                                              |                                                        |
| $Q_s / Q_c$ | 0 - 1.0    | $\leq 0.5$                                           | $> 0.5$                                                |
| $\tau_{st}$ | 0.4        | $2 \cdot \left( 2 \cdot \frac{Q_s}{Q_c} - 1 \right)$ | $0.3 \cdot \left( 2 \cdot \frac{Q_s}{Q_c} - 1 \right)$ |

([1] diagram 7-20)

■  $2000 < Re_c < 4000$

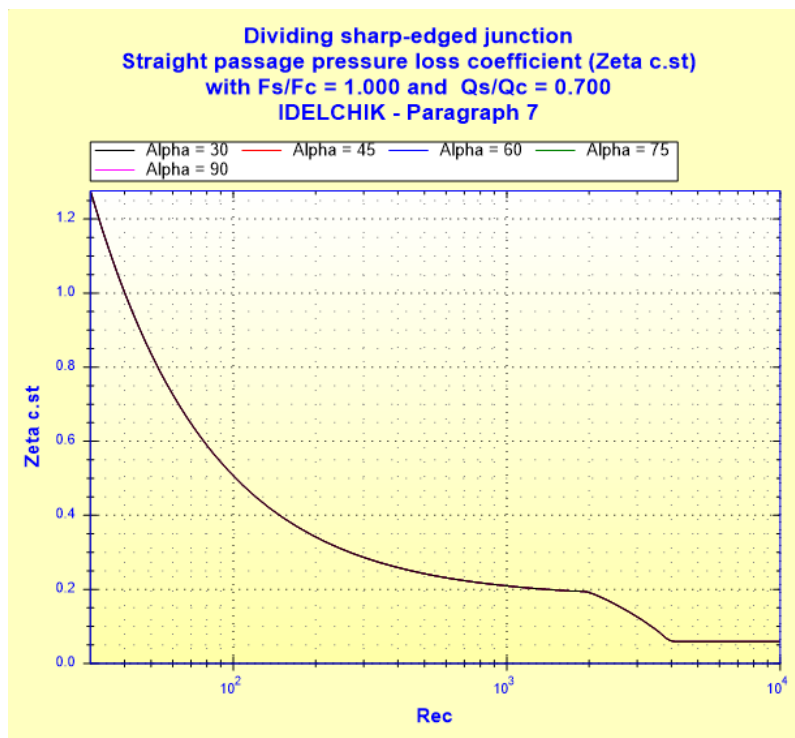
linear interpolation

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

with:

$\zeta_{c.st}^l$  = laminar coefficient obtained with  $Re_c = 2000$

$\zeta_{c.st}^t$  = turbulent coefficient obtained with  $Re_c = 4000$



$\zeta_{c.st}$  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 (m <sup>2</sup> )                                       |
| $F_c$            | Cross-sectional area of the common branch and the straight branch (m <sup>2</sup> )                |
| $Q_s$            | Volume flow rate in the lateral branch (m <sup>3</sup> /s)                                         |
| $w_s$            | Mean velocity in the lateral branch (m/s)                                                          |
| $Q_{st}$         | Volume flow rate in the straight branch (m <sup>3</sup> /s)                                        |
| $w_{st}$         | Mean velocity in the straight branch (m/s)                                                         |
| $Q_c$            | Volume flow rate in the common branch (m <sup>3</sup> /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 ( )                                                           |
| $\alpha$         | Angle of the lateral branch (m)                                                                    |
| $\zeta_{c.s}^l$  | Pressure loss coefficient of the lateral branch in laminar flow ( )                                |
| $\zeta_{c.st}^t$ | Pressure loss coefficient of the straight branch in turbulent flow ( )                             |
| $\zeta_{c.s}$    | 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) ( ) |
| $\Delta P_s$     | Pressure loss in the lateral branch (Pa)                                                           |
| $\Delta P_{st}$  | Pressure loss in the straight branch (Pa)                                                          |
| $\Delta H_s$     | Head loss of fluid in the lateral branch (m)                                                       |
| $\Delta H_{st}$  | 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)                                                    |
| $\rho$           | Fluid density (kg/m <sup>3</sup> )                                                                 |

- $\nu$  Fluid kinematic viscosity ( $\text{m}^2/\text{s}$ )
- $g$  Gravitational acceleration ( $\text{m}/\text{s}^2$ )

**Validity range:**

- angle of the lateral branch: between  $30^\circ$  and  $90^\circ$

**Example of application:**

The screenshot displays the HydraulCalc 2019a interface for a 'Dividing sharp-edged junction - IDELCHIK (3rd Ed.)'. It is divided into three main sections:

- Fluid characteristics:** Shows fluid properties for Water @ 1 atm [HC]. Temperature is 20 °C, pressure is 1.013 bar. Density is 998.2061 kg/m³, dynamic viscosity is 0.00100159 N.s/m², and kinematic viscosity is 1.00340E-06 m²/s. A graph plots Density (kg/m³) vs Temperature (°C).
- Geometrical characteristics:** Shows a 3D diagram of a T-junction with a 90-degree angle. Key parameters include:
  - Main pipe diameter  $D_c = 0.0703$  m
  - Main pipe flow rate  $Q_c = 0.0060$  m³/s, velocity  $w_c = 1.546$  m/s (Turbulent)
  - Side branch diameter  $D_s = 0.0431$  m
  - Side branch flow rate  $Q_s = 0.001$  m³/s, velocity  $w_s = 0.685$  m/s (Turbulent)
  - Common channel flow rate  $Q_{st} = 0.005$  m³/s, velocity  $w_{st} = 1.288$  m/s (Turbulent)
  - Side branch pressure loss  $\Delta P_s = 0.01284362$  bar, head loss  $\Delta H_s = 0.1312$  m of fluid
  - Straight passage pressure loss  $\Delta P_{st} = 0.0001325102$  bar, head loss  $\Delta H_{st} = 0.0014$  m of fluid
- Complementary results:** A table listing various hydraulic parameters and their values.

| Designation                                                  | Symbol    | Value       | Unit         |
|--------------------------------------------------------------|-----------|-------------|--------------|
| Side branch cross-section area                               | $F_s$     | 0.001458963 | $\text{m}^2$ |
| Straight passage cross-section area                          | $F_{st}$  | 0.003881508 | $\text{m}^2$ |
| Common channel cross-section area                            | $F_c$     | 0.003881508 | $\text{m}^2$ |
| Cross-sections area ratio 'Side branch / Common channel'     | $F_s/F_c$ | 0.3758754   |              |
| Flow rate ratio 'Side branch / Common channel'               | $Q_s/Q_c$ | 0.1666667   |              |
| Velocity ratio 'Side branch / Common channel'                | $w_s/w_c$ | 0.4434094   |              |
| 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' (Diagram 7-18)                                | $A'$      | 0.9         |              |
| Coefficient (Diagram 7-18)                                   | $C_{cs}$  | 1.196612    |              |
| Coefficient (Diagram 7-20)                                   | $T_{st}$  | 0.4         |              |
| Straight passage pressure loss coefficient (based on $w_c$ ) | $C_{cst}$ | 0.01111111  |              |
| Side branch pressure loss coefficient (based on $w_c$ )      | $C_{cs}$  | 1.076951    |              |
| Side branch hydraulic power loss                             | $W_{hs}$  | 1.284362    | W            |
| Straight passage hydraulic power loss                        | $W_{hst}$ | 0.06625509  | W            |

**References:**

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