Fluid Mechanics MTF053

Flow in Non-Circular Ducts

Complementary Material

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Hydraulic Diameter

For non-circular cross section ducts, the diameter D is replaced with the hydraulic diameter D_h calculated as

$$D_h = \frac{4A}{\mathcal{P}} \tag{1}$$

The Reynolds number based on the hydraulic diameter Re_{D_h} is obtained as

$$Re_{D_h} = \frac{VD_h}{\nu} \tag{2}$$

where A is the cross-section area and $\mathcal{P}$ is the wetted perimeter.

Turbulent Flow

Use the same formulas (or the Moody chart) as for flow in circular pipes but replace the diameter with the hydraulic diameter D_h

$$\Delta p_f = f\frac{L}{D_h}\frac{\rho V^2}{2} \tag{3}$$

Non-dimensional surface roughness is calculated as

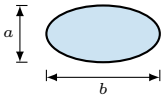
$$\frac{\varepsilon}{D_h} \tag{4}$$

Laminar Flow

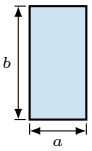
Calculate the friction factor as

$$f = \frac{C}{Re_{D_h}} \tag{5}$$

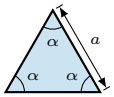
where Re_{D_h} is the Reynolds number based on the hydraulic diameter and C is a constant that depends on duct shape (for circular cross sections $C = 64$ and $D_h = D$). The table below gives values of C for a selection of cross sections.



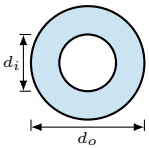
a/b	D_h	C
0.7	$1.17a$	65.0
0.5	$1.30a$	68.0
0.3	$1.44a$	73.0
0.2	$1.50a$	78.0
0.1	$1.55a$	79.0



b/a	D_h	C
1.0	$1.00a$	57.0
1.25	$1.11a$	57.6
2.0	$1.33a$	62.0
3.0	$1.50a$	69.0
4.0	$1.60a$	73.0
5.0	$1.67a$	78.0
8.0	$1.78a$	83.0
10.0	$1.82a$	85.0

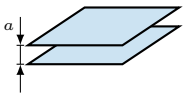


D_h	C
$0.58a$	53.0



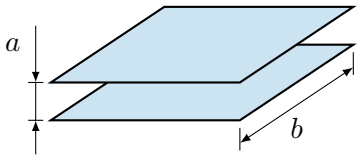
d_i/d_o	C
$\frac{d_i}{d_o} = 0.10$	89.2
$\frac{d_i}{d_o} = 0.25$	94.0
$0.5 < \frac{d_i}{d_o} < 1.0$	96.0

$D_h = d_o - d_i$



D_h	C
$2.0a$	96.0

Flow Between Parallel Plates



- vertical distance between plates: a
- plate width: b

$$D_h = \frac{4A}{\mathcal{P}} = \frac{4ab}{2a+2b}\bigg|_{b\to\infty} = \frac{4ab}{2b} = 2a$$