Chapter 3
Hydrodynamic lubrication (HL)

Lubrification hydrodynamique

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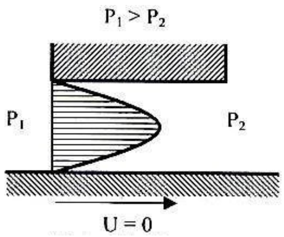
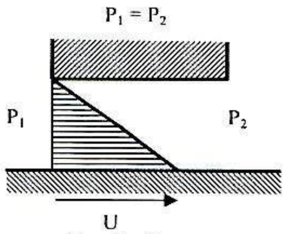
Hydrostatic bearings
Paliers hydrostatiques

Application: high loads and/or low speeds

Poiseuille velocity >> Couette velocity





1D case: $$u(y) = \frac{1}{2\eta}\frac{dp}{dx}\, y\,(y-h) + u_1\left(1 - \frac{y}{h}\right)$$

$$\frac{h^2}{4\eta}\frac{dp}{dx} >> u_1$$

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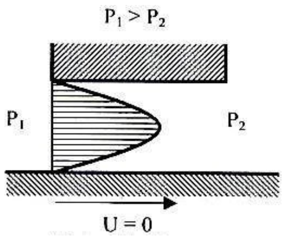
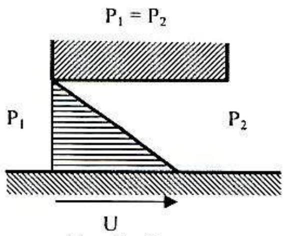


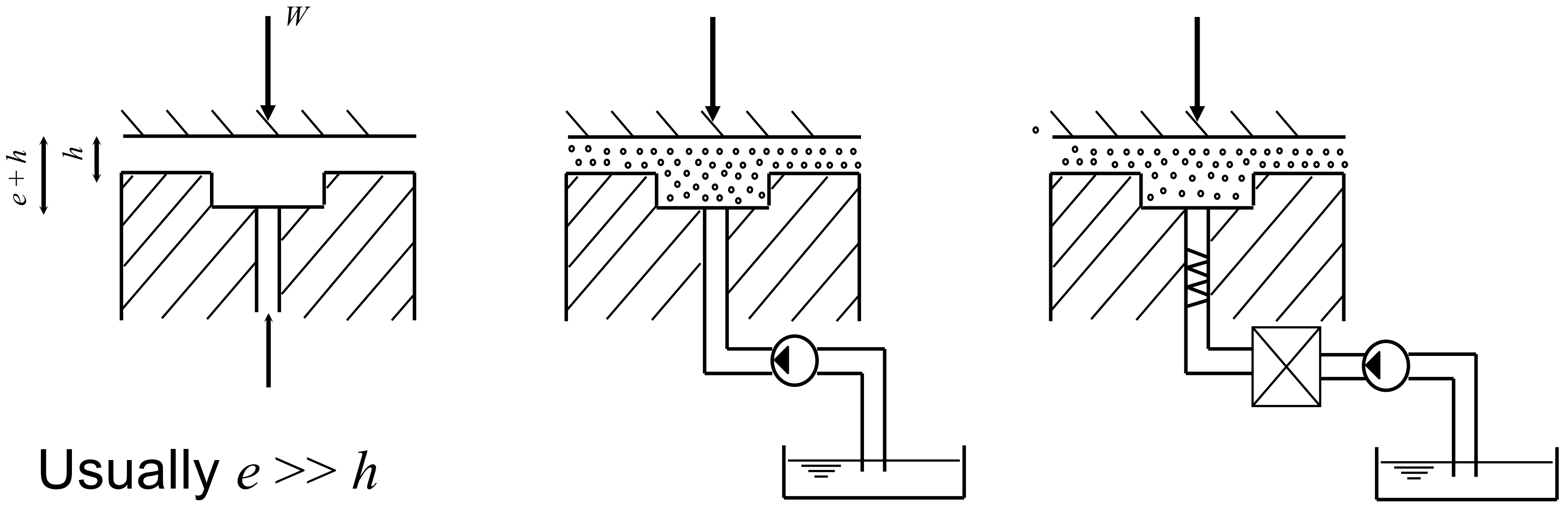


Simplification in 1D Reynolds equation:

$$\frac{\partial}{\partial x}\left(\frac{\rho h^3}{12\eta}\frac{\partial p}{\partial x}\right) = \frac{\partial}{\partial x}\left(\rho h \frac{u_1 + u_2}{2}\right) + \frac{\partial}{\partial t}(\rho h)$$

0 for stationary case

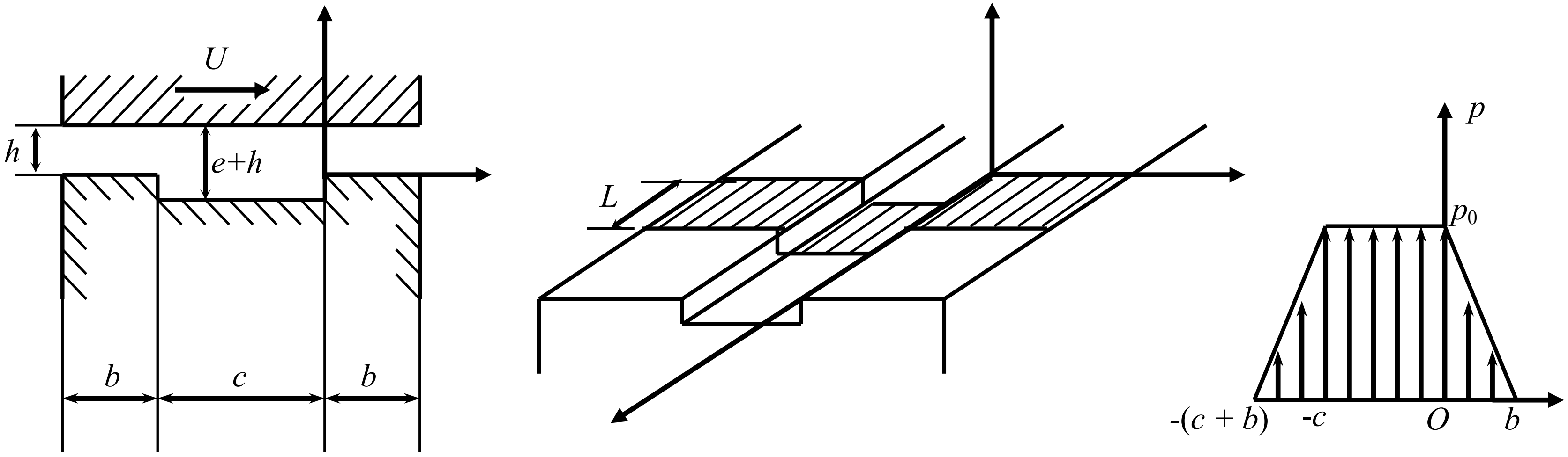
Examples



Usually $e >> h$

Example: Hydrostatic thrust bearing

Exemple : butée hydrostatique



$$e >> h$$

$$\frac{d^2 p}{d x^2} = 0$$

$$W = ?$$

Flow calculation

Calcul du débit

$$u(z) = \frac{1}{2\eta}\frac{dp}{dx}\,z\left(z-h\right) + \frac{uz}{h}$$

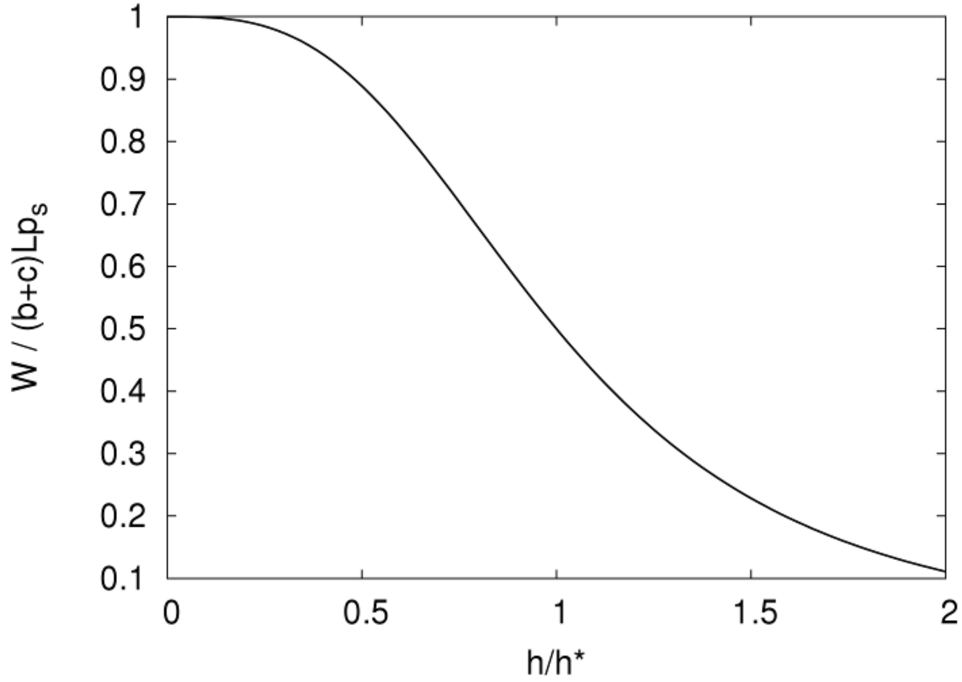
$$\frac{Q}{L} = \int_0^h u(x=b)\,dz - \int_0^h u(x=-b-c)\,dz \;= \frac{h^3 p_0}{6\eta b}$$

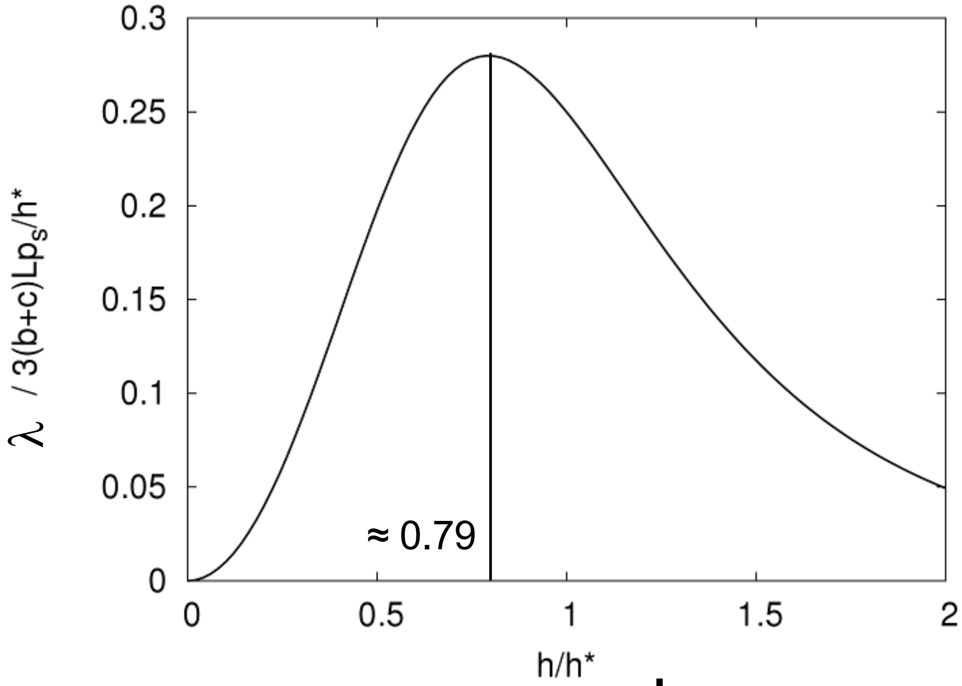
Why is $Q \propto p_0$ and $Q \propto 1\,/\,b$?

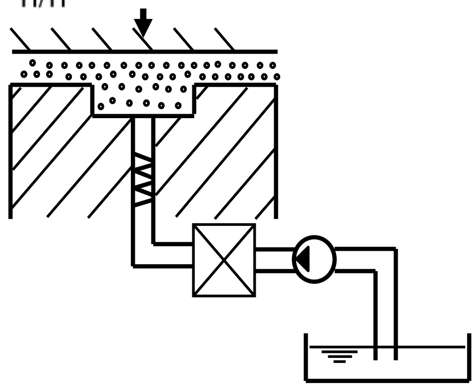
Stiffness

Rigidité

Using an additional device, e.g. a capillary

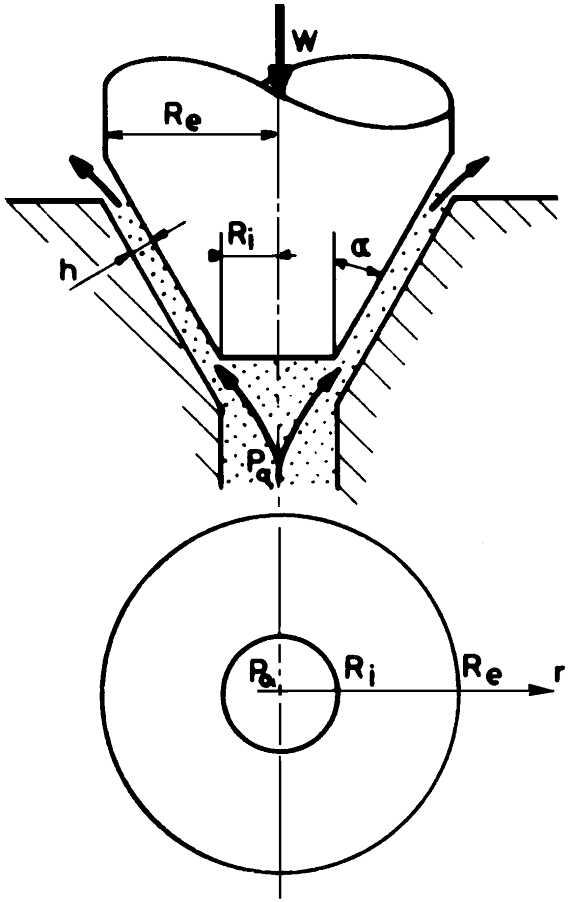






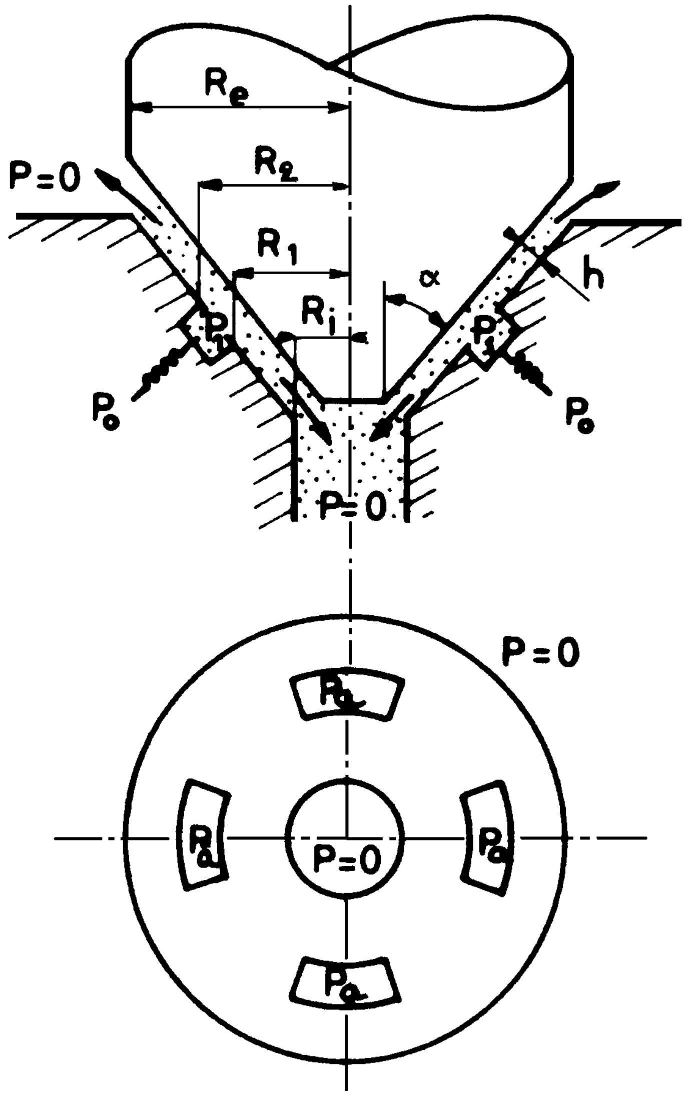
Example: Conical thrust bearing

Exemple : butée conique



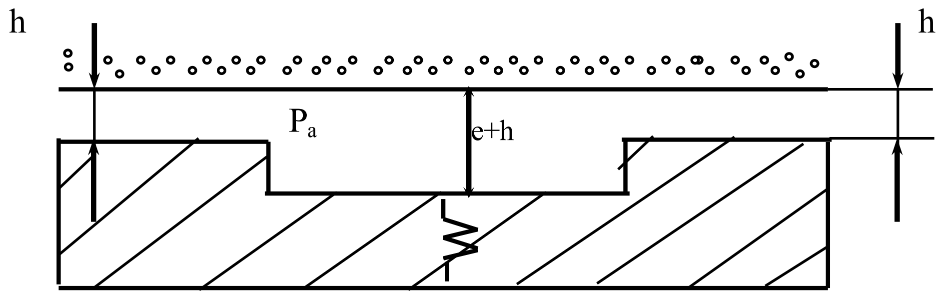
Example: Conical thrust bearing

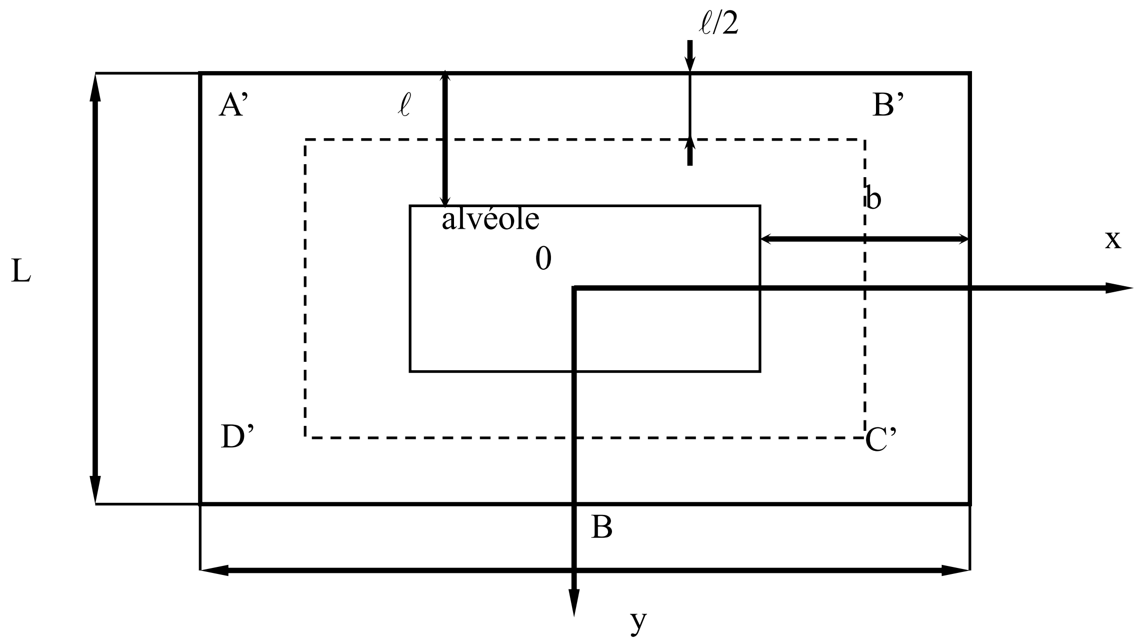
Exemple : butée conique



Pressure distribution 2d example

2e exemple de distribution de pression

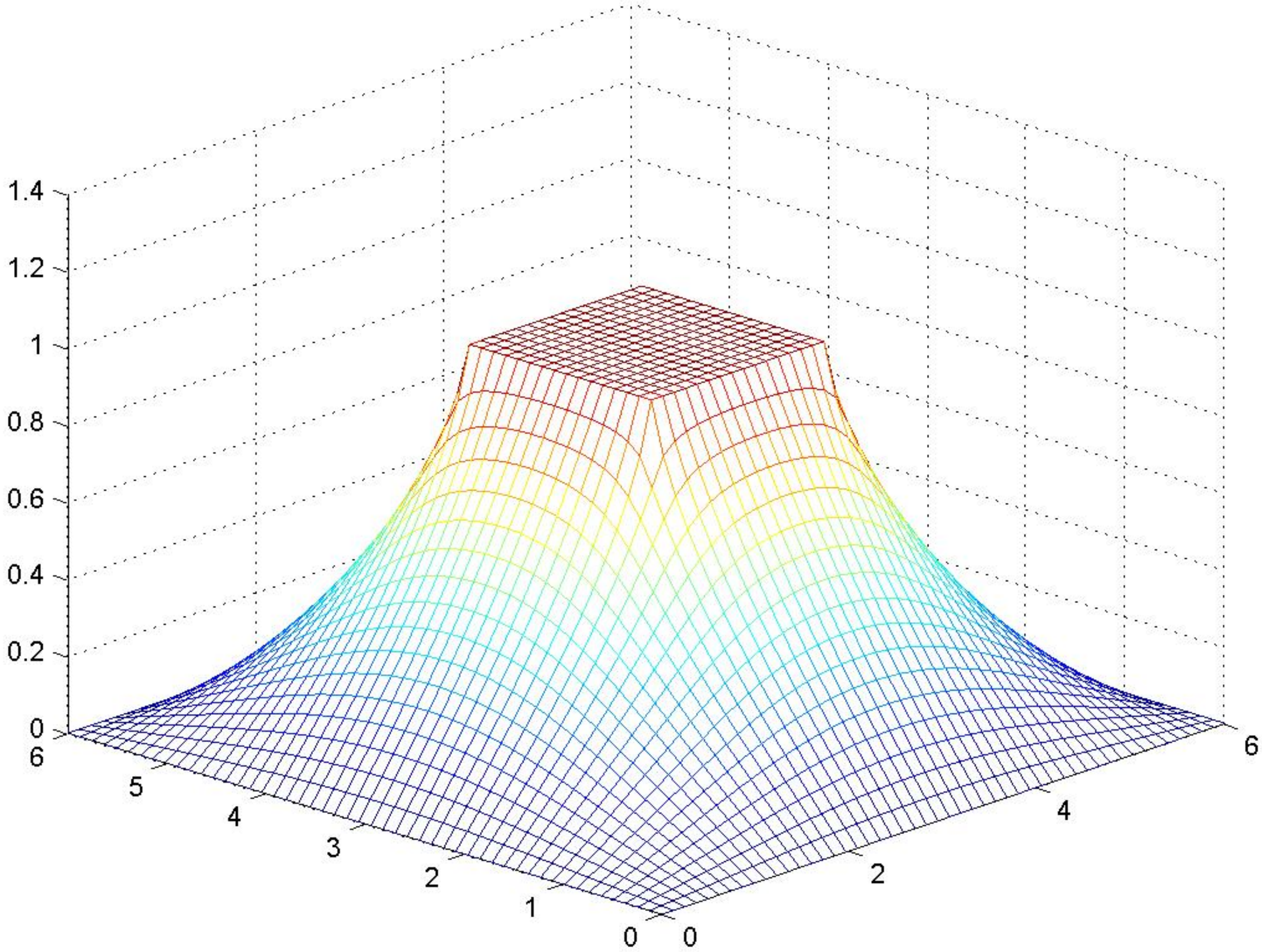




Numerical calculations of the pressure distribution are required

Pressure distribution 2d example

2e exemple de distribution de pression



Hydrostatic thrust bearings: Conclusion

Conclusion pour les butées hydrostatiques

☺ separation even at low (zero) velocity

☺ distributed (low) pressure ⇒ no fatigue

☺ tolerates rather poor surface finish

☹ size, weight and cost (initial and functional)