Flow induced oscillation of a cylinder between two walls

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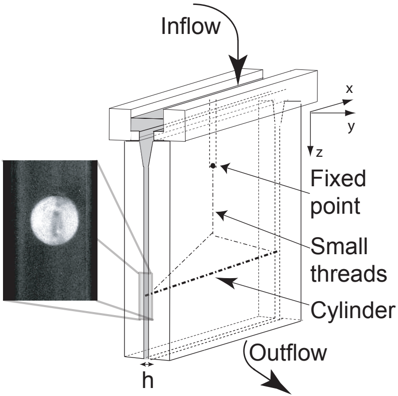
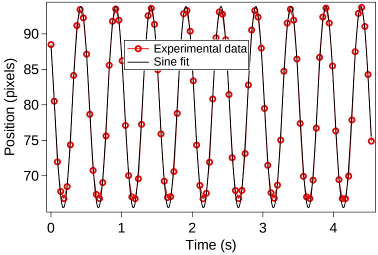
Introduction: experiment

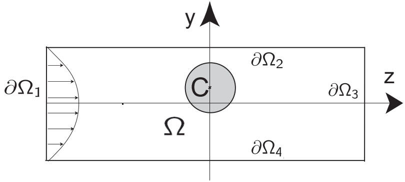


- Fluid: water
- Steady flow at the entrance
- $h = 4.9$ mm: aperture
- $d = 3.2$ mm: diameter of the cylinder ; $d/h = 0.66$
- $\rho_{cylinder}/\rho_{fluid} = 1.19$
- $Re = \rho_f h U_{mean}/\eta$: Reynolds number



$Re = 50$

2D modelling: fluid



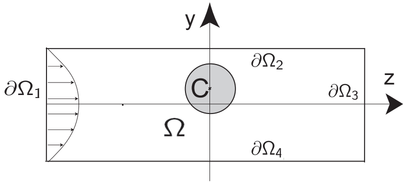
- Navier-Stokes

$$\begin{cases} \left(\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u}.\nabla)\mathbf{u}\right) - \frac{1}{Re}\Delta \mathbf{u} + \nabla p = 0 \text{ in } \Omega \backslash \bar{C} \\ \nabla.\mathbf{u} = 0 \text{ in } \Omega \backslash \bar{C} \end{cases}$$

- Boundary conditions:

$$\begin{cases} \mathbf{u} = -6y(y-1)\mathbf{e}_z \text{ on } \partial\Omega_1 \\ \mathbf{u} = 0 \text{ on } \partial\Omega_2 \cup \partial\Omega_4 \\ \sigma.\mathbf{n} = 0 \text{ on } \partial\Omega_3 \\ \mathbf{u} = \mathbf{V} \text{ on } \partial C \end{cases}$$

2D modelling: cylinder



- Cylinder (C):

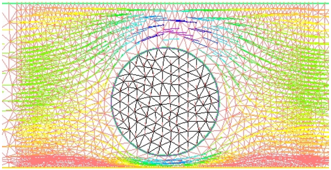
$$\begin{cases} \mathbf{u} = \mathbf{V(t)} = \mathbf{constant(t)} \text{ (rigid motion without rotation)} \\ \mathbf{u}.\mathbf{e}_z = 0 \text{ (no translation along } \mathbf{e}_z\text{)} \end{cases}$$

- Boundary conditions:

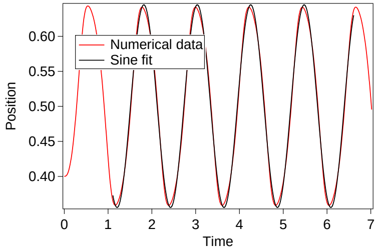
$$M\frac{\mathrm{d}\mathbf{V}}{\mathrm{d}t} = -\int_{\partial C} \sigma.\mathbf{n}\mathrm{d}S$$

Numerical method

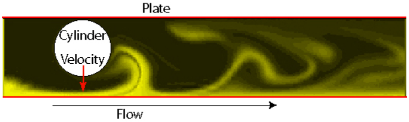
- Finite element solver: Freefem++
- Variational form written on the whole fluid/solid domain
- Handling of constraints:
  - penalty method for the constant velocity in C
  - duality for $\mathbf{u}.\mathbf{e}_z = 0$
- Contact with plates handled by setting a small minimal approach distance
- Mesh moving with the cylinder using an Arbitrary Lagrangian Eulerian formulation



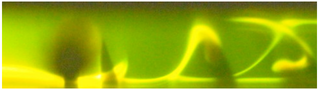
Numerical results: oscillations



Re=50

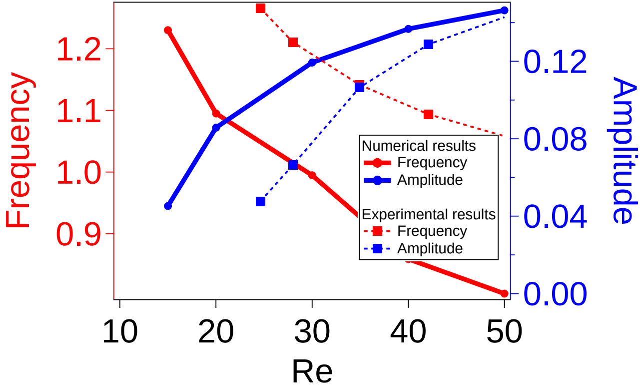


Numerical result (concentration map) of dye injection ($Re = 50$)



Experimental result ($Re = 50$)

Variation with *Re* and perspectives



Parameters are made dimensionless using U_{mean}, h and ρ_f

Perspectives

- Improve quantitative agreement with experiments
- Use numerical results to better understand the phenomenon