Study of the movement of a subsurface buoy with 5 degrees of freedom

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USE OF SUBSURFACE BUOYS

- Subsurface buoys are used in offshore engineering to reduce the mechanical constraints on underwater structures.

- With their cylindrical shape and low mass, they are very sensitive to Vortex Induced Vibrations (VIV)

- Burning issues for oil platforms or floating wind turbines.

OBJECTIVES

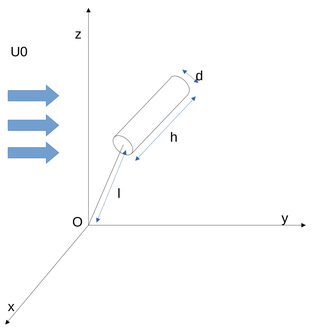
- Characterize experimentally the movement of a cylindrical buoy in transverse flow

- Simulate numerically the movement of the buoy with the code CADYF

- Compare experimental and numerical results

MODEL

- A cylindrical tethered buoy submit to a transverse flow



- 3 distances (x_c, y_c, z_c) to describe the position of the center of mass of the buoy

- 3 angles (θ, φ, β) to describe the orientation of the buoy

- 1 constraint (the cable is inextensible)

Thus, **a 5 degrees of freedom model**

PARAMETERS AND DIMENSIONLESS NUMBERS

d : diameter of the cylindrical buoy
h : height of the buoy
l : length of the cable
U_0: flow velocity
g : standard gravity
η : dynamic viscosity of the fluid
ρ : density of the fluid
m: mass of the buoy
I_a: inertia of the cylinder along a main axis
I_b : inertia of the cylinder along the other main axis

$Re = \frac{\rho U_0 d}{\eta}$	: Reynolds number
$\mathcal{M} = \frac{\rho h d^2}{4m}$	: Mass Number
$Fr = \frac{U_0}{\sqrt{gd}}$	: Froude Number
$A_1 = \frac{h}{d}$, $A_2 = \frac{l}{d}$	: Geometrical ratios
$B_1 = \frac{I_a}{I_b}$, $B_2 = \frac{8 I_b}{m d^2}$	: Inertial Ratios

EXPERIENCES

Infrastructures :

Use of the hydrodynamic loop of the A106 room of EPM. The hydrodynamic tunnel where experiments are carried out has a squared section of 25 cm.

Use of the hydrodynamic loop of the A106 room

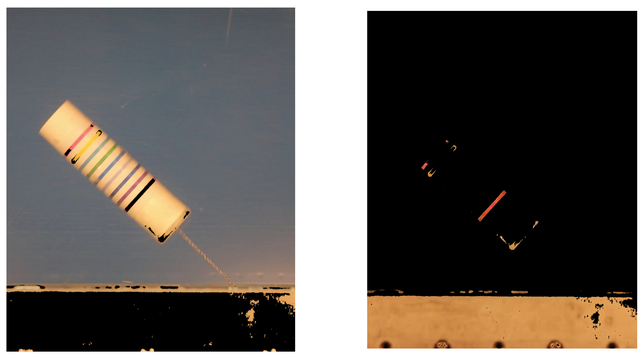
Hydrodynamic conditions :

$$Re = 1 \times 10^3 - 2 \times 10^4$$
$$\mathcal{M} = 0.1 - 0.9$$
$$Fr = 0.26 - 1.8$$

Methodology :

The buoy in transverse flow is filmed with a SLR camera, and its position is reconstructed with image analysis methods.

Actual work : Image analysis and form recognition :

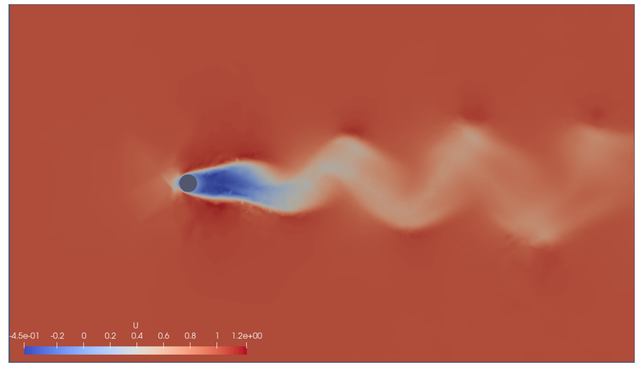


Recognition of a specific color (filtered image and its negative) with OpenCV library

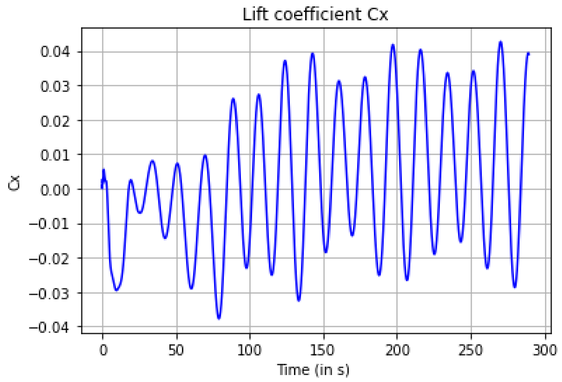
NUMERICAL SIMULATIONS

CFD :

Use of the code CADYF. CADYF is a monolithic FEM code for fluid mechanics and fluid structure interactions.



Karman Vortex Street behind a fixed cylinder at Re = 200 with CADYF



Lift coefficient Cx at Re = 200

Hydrodynamic conditions :

$$Re = \text{ up to } 5 \times 10^2$$
$$\mathcal{M} = \text{no constraint}$$
$$Fr = \text{no constraint}$$

Actual work :

Developpement and implementation of specific equations for the translation and rotation of a tethered cylindrical buoy

ACKNOWLEDGMENTS

CRSNG NSERC

GPS Génie par la simulation SBES Simulation - Based Engineering Science