Fluid-Structure Interaction effects on the pitching and heaving deformable plate dynamics in a fluid flow

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Numerous prototypes of underwater current energy harvester have been developed in the past decade. Most of them are based on rotating [1, 2] or oscillating [3] technologies which undergo significant water loads. While the first technology is the most advanced, the latter features interesting advantages such as a larger number of potential extraction sites and has shown promising performance [4]. The hostile environment can be damaging and can strongly affect the dynamics of the structure. This is why, fluid-structure interaction applications are generating more and more interest in numerous fields of research and industry. Lately, with the increase of computing power and the progress made in partitioned coupling procedures, realistic and efficient simulations are now viable at full scale [5]. Finally, many studies can be found on 2D non deformable oscillating structure [6]. However, few of them took into account the fluid-induced deformation of the solid due to Fluid-Structure Interactions (FSI).

This study presents a numerical investigation of a 2D flexible flat plate dynamics, immersed in a fluid flow with a Reynolds number, based on its chords, of 2000. The plate is animated by a forced sinusoidal pitching and heaving movement. Various materials of the structure are studied, from the rigid material to a more flexible one. The Fluid-Structure Interaction (FSI) effects are taken into account using a partitioned implicit coupling scheme. The Arbitrary Lagrangian-Eulerian (ALE) formulation of the Navier-Stokes equations is applied and the anisotropic diffusion equation is solved to determine the displacement of the fluid domain mesh. Both the viscous incompressible Navier-Stokes equations and the linear elasticity equation are solved using finite volume method. Analysis are based on the hydrodynamic loads, and thereby on the dynamic and the power coefficient of the structure.

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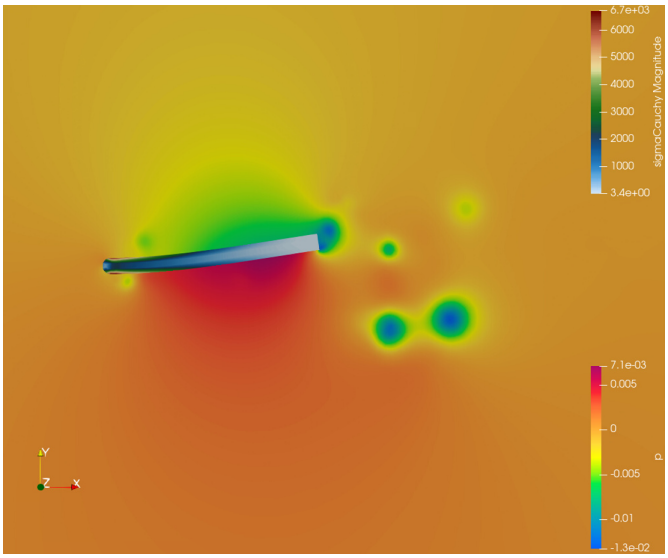

FIGURE 1 – Pressure and Cauchy stress fields of a pitching flexible flat plate.

Références

[1] U. Ahmed, D. D. Apsley, I. Afgan, T. Stallard, and P. K. Stansby. Fluctuating loads on a tidal turbine due to velocity shear and turbulence : Comparison of CFD with field data. *Renewable Energy*, 112 :235–246, November 2017.

[2] M. Belhache, S. Guillou, P. Grangeret, D. Mouazé, and A. Santa-Cruz. Wake numerical study of a vertical marine current turbine. *La Houille Blanche*, (6) :74–78.

[3] T. Kinsey and G. Dumas. Optimal Operating Parameters for an Oscillating Foil Turbine at Reynolds Number 500,000. *AIAA Journal*, 52(9) :1885–1895, April 2014.

[4] William McKinney and James DeLaurier. Wingmill : An Oscillating-Wing Windmill. *Journal of Energy*, 5(2) :109–115, March 1981.

[5] A. Korobenko, J. Yan, S. M. I. Gohari, S. Sarkar, and Y. Bazilevs. FSI Simulation of two back-to-back wind turbines in atmospheric boundary layer flow. *Computers & Fluids*, 158(Supplement C) :167–175, November 2017.

[6] Qing Xiao and Qiang Zhu. A review on flow energy harvesters based on flapping foils. *Journal of Fluids and Structures*, 46(Supplement C) :174–191, 2014.