INFLUENCE OF THE CIRCULAR CYLINDER CROSS-SECTION VARIATION ON THE NEAR WAKE BEHAVIOUR

Oualli Hamid*, Hanchi Samir**, Bouabdallah Ahcene*, Askovic Radomir***
** LTSE,Physics Institute,University of Sciences & Technology (USTHB), 16111 Algiers, Algeria*
***MDF,Department of Mechanics EMP, Bordj El Bahri, 16111 Algiers, Algeria*
**** LME, UVHC, 59313 Valenciennes Cedex 9, France*

Summary The present study is both numerical and experimental. Numerically, Navier-Stocks equations in vorticity formulation are solved using finite differences method and taking into account the superimposed vibrating motion. Experimentally, a setup is conceived and realised. Investigations are carried out around a deformable cylinder using flow visualisations, PIV and anemometry techniques. Important results on the drag coefficient Cd, primary and secondary vortices interplay, heat transfer around the cylinder and the shedding mechanism are obtained and discussed.

This study is concerned with the understanding of the flow phenomena which occur in the wake of a circular cylinder superimposed to radial oscillation. The Reynolds numbers investigated herein extend along the range of the onset of the transition in the shear layers. The work is both experimental and numerical. Experiments are carried out in an aerodynamic subsonic wind tunnel which led to interesting conclusions completed with some numerical results. The influence of a radial pulsative motion of a circular cylinder, fig1 and 2, on the primary and secondary vortices of the wake is investigated by means of smoke visualisations, PIV and hot wire techniques. Important results on the bluff body drag coefficient Cd are obtained. In fact, the Cd rate of fluctuation increases considerably while the corresponding mean value $C\bar{d}$ decreases correspondingly, to reach negative values making the cylinder to be propelled in the streamwise direction, fig3. A spectral analysis showed that the flow tends to reorganisation in response to the applied actuation. The fundamental harmonic of the spectrum for the actuated cylinder case reduces to half of the value of the non controlled configuration, fig4 and 5. A calculation code using finite differences method for the viscous vortex street behind a circular cylinder is developed and has applications for the simulation of the vorticity field in the near wake, the shedding mechanism and drag coefficient. The near wake response to the imposed perturbation and an understanding of the various induced modifications is subsequently achieved.

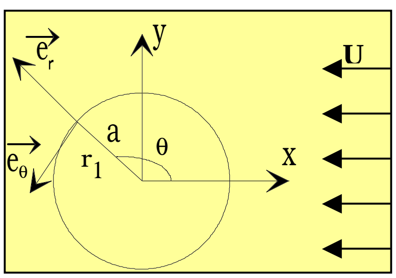

Fig1. System of coordinates

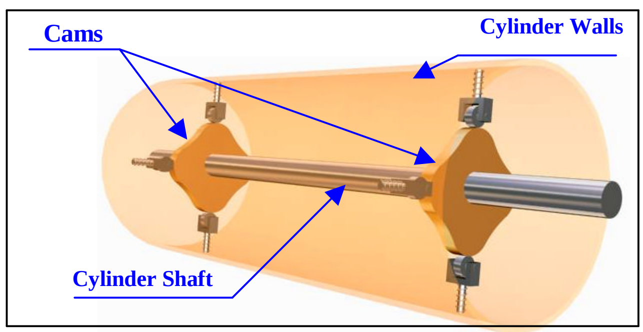

Fig2. Deforming cylinder

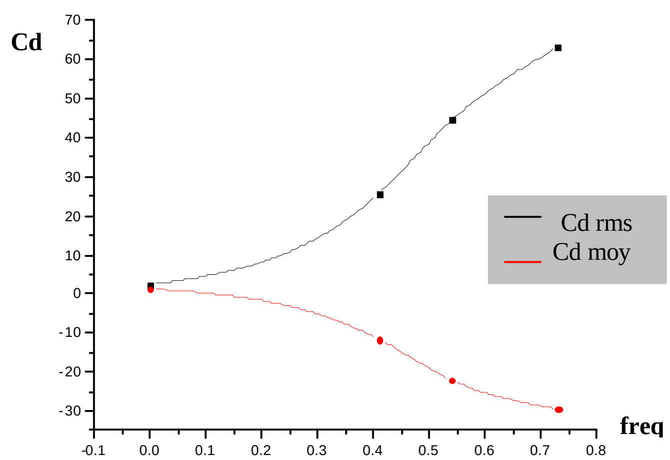

Fig3. Drag coefficient variation for an actuated circular cylinder for Re = 9500

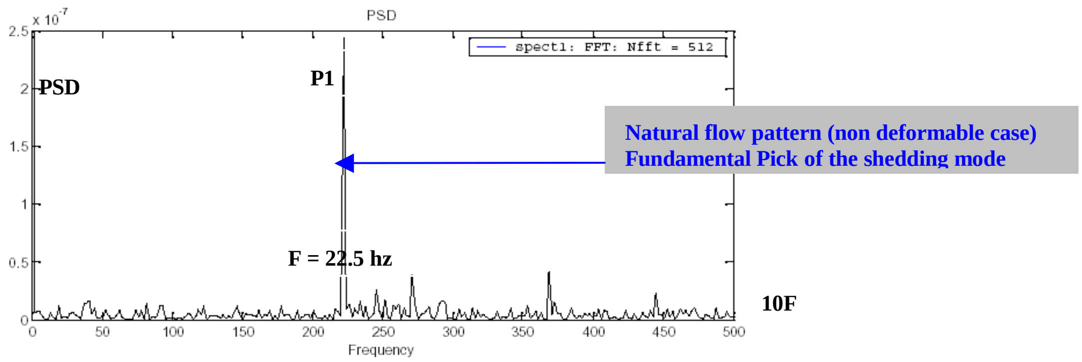

Fig4. Power Spectral Density for a flow around a cylinder at rest, f = 0hz et St = 0.176

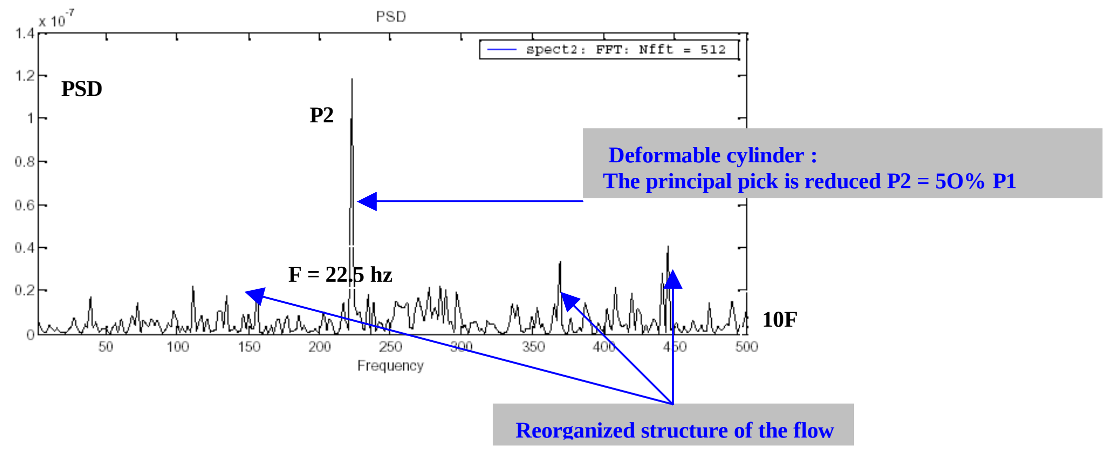

Fig5. Power Spectral Density for a flow around a deformable cylinder, f = 0.66hz et St = 0.176

CONCLUSION

The proposed actuating method allows to enhance or retard turbulence according to superimposed conditions by means of frequency and amplitude of deformation. Convection is considerably increased with the continuously renewed fluid in the cylinder vicinity. Moreover, alteration of the shedding mechanism makes the lock-in phenomenon, for instance, around bridges and thick electrical wires can be avoid as well as cavitation effects in hydrodynamic fluids. When the superimposed frequency is increased the mean value of the drag coefficient decreases drastically and becomes even negative propelling thus the cylinder.

References

[1]
Frequency of a Radially Deforming Circular Cylinder impulsively Started on Cylinder Wake, Int. J. Num. Meth. Fluids. 41 (2003) 905-930.

[2] Shiels D., Leonard.A: Investigation of a drag reduction on a circular cylinder in rotary oscillation, J. Fluid Mech 100 (2001) 431, 297-322.

[3] Zdravkovich M.M.: Flow Around Circular Cylinders, Oxford Sc. Publications, Vol 1, (1997).

[4] Koumotsakos P., Leonard A.: High-Resolution Simulations of the Flow Around an Impulsively Started Cylinder Using Vortex Method, J. Fluid Mech. 196 (1995) 1-38.

[5] Coutanceau M., Defay, J. R.: Circular Cylinder Wake Configuration, App. Mech. Rev., Vol. 44, No.6, pp 255-305, (1991).

[6] Ta Phuoc Loc, Bouard R.: Numerical solution of the early stage of the unsteady viscous flow around a circular cylinder: A comparison with experimental visualisation and measurements, J. Fluid Mech 160(1985) 93-117.