Frequency and amplitude modulation in the wake of an inline driven cylinder

- BIFD2011 -

Justin S. Leontini*†, David Lo Jacono‡⋆, Mark C. Thompson†

† Fluids Laboratory for Aeronautical and Industrial Research (FLAIR), Department of Mechanical and Aerospace Engineering
Monash University, Wellington Rd., Clayton, Victoria, 3800 Australia
e-mail: justin.leontini@monash.edu, mark.thompson@monash.edu
web page: http://www.flair.monash.edu

‡Université de Toulouse; INP; IMFT (Institut de Mécanique des Fluides de Toulouse), Allée Camille Soula, F-31400 Toulouse, France

⋆CNRS; IMFT; F-31400 Toulouse, France
e-mail: david.lojacono@imft.fr - Web page: http://www.imft.fr

ABSTRACT

Simulations of a cylinder undergoing externally-controlled sinusoidal oscillations in the freestream direction have been performed, similar to previous experimental [1] and numerical [2] studies. Interest in this problem stems from the fact that the symmetry of the forcing is different from the symmetry of the natural Kármán vortex street of the unperturbed wake. The focus was kept on the case where the frequency of oscillation was equal to the vortex shedding frequency from a fixed cylinder, while the amplitude of oscillation was varied.

For low to moderate amplitudes, the wake dynamics appear to be controlled by a new global mode modified by the driven oscillation. The frequency of this global mode, which is essentially a new frequency of vortex shedding, is a function of the driving amplitude.

The frequency of vortex shedding shows slight deviations in the regions where the new shedding frequency and the driving frequency make an integer ratio. Here, the flow synchronises to a subharmonic of the driving frequency. At least 6 of these P_N modes (periodic over N oscillation cycles) have been identified. These P_N modes occur in a series, interleaved with regions of quasiperiodicity, with N decreasing with increasing amplitude of oscillation, until synchronisation to a P_2 mode.

Spectra of the lift force show numerous frequencies as well as the new shedding frequency, however the driving frequency does not appear. Instead, the frequency components present consist of the sum and difference of the new shedding frequency with integer multiples of the driving frequency. These components are explained by considering the lift as a sinusoid at the new shedding frequency, which is frequency modulated by the driving frequency, and then further amplitude modulated. The frequency modulation is explained by considering the body as a wave generator. This wave generator model, coupled with the synchronisation phenomenon, appears to explain the behaviour of the wake up until amplitudes where the P_2 mode loses stability to chaotic oscillations.

REFERENCES

[1] A. Ongoren, D. Rockwell *Flow structure from an oscillating cylinder Part 2. Mode competition in the near wake*, J. Fluid Mech. **191**, 225-245, 1988.

[2] Paris G. Perdikaris, Lambros Kaiktsis, George S. Triantafyllou *Chaos in a cylinder wake due to forcing at the Strouhal frequency*, Phys. Fluids **21**, 101705, 2009.